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**Strategic Fit Between Green Supply Chain  
Integration and Green Innovation Goals on the  
circular economy: An empirical study on Finnish  
Manufacturing Industry**

School of Technology and Innovation  
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**ABSTRACT:**

This thesis investigates the strategic alignment between Green Supply Chain Integration (GSCI) and Green Innovation and their impact on Circular Economy (CE) performance in Finnish manufacturing industry. As global demand increases, for that sustainable production and resources utilization are facilitated by GSCI and GI, with the circular economy plays a crucial enabler to achieve the objectives. While each of them has been done researched independently with a large degree, but strategic alignment with each other and their impact on performance of circular economy have not been amply examined, especially in Finland's advance manufacturing context.

The problem of the research has been addressed by determining how GSCI dimensions are related to green innovation behaviors and how they, in turn, affect CE outcomes such as resource efficiency, waste minimization, recycling, and product life extension. The theoretical model has been developed by integrating the Triple Bottom Line (TBL) theory, providing a structured window to study the interconnections among resources, behavior, and performance effects in sustainable manufacturing.

A quantitative research design has been adopted; wherein primary data have been collected through questionnaire from Finnish manufacturing firms engaged in sustainable practices. A non-probability convenience sampling approach has been employed to cover organizations that have continuous sustainability and CE activities. Data has been analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) to evaluate measurement constructs and test hypothesized relationships, including mediation effects of green innovation between GSCI and CE performance.

Empirical evidence has shown that higher levels of integration among internal operations, suppliers, and customers have been associated with stronger green innovation capabilities that has been supporting long-term CE objectives with strategic alignment in Finnish manufacturing firms. The suggested framework gives a clear picture of practical as well as theoretical insights with managerial guidelines on how to integrate sustainability into organizational strategy more effectively. The research also highlights future areas of study that include the institutional drivers and uses of the strategic fit model in different industries.

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**KEYWORDS:** Supply chain management, green supply chain integration, green innovation, Circular economy, Triple bottom line, Finnish manufacturing industry, Structural Equation Modelling.

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**Abbreviations**

ASC	Autonomous supply chain
CE	Circular Economy
ECSC	Environmentally Friendly Supply Chains
EIGI	Exploitative Green Innovation
ERGI	Exploratory Green Innovation
ESC	Environmental Supply Chains
GCI	Green customer Integration
GI	Green Innovation
GII	Green Internal Integration
GSCI	Green Supply Chain Integration
GSI	Green Supplier Integration
OECD	Organization for Economic Co-operation and Development
PLS-SEM	Partial Least Squares Structural Equation Modeling
RBP	Resource–Behavior–Performance
SC	Supply Chain
SCI	Supply Chain Integration
SCM	Supply Chain Management
SCO	Supply Chain Orientation
SEM	Structural Equation Modeling
SMEs	Small and Medium Enterprises
TBL	Triple Bottom Line Theory

# 1 Introduction

The increasing pressure of climate change, environmental degradation, and depletion of natural resources has placed enormous pressure on industries to adopt more sustainable consumption and production patterns. The manufacturing sector has been facing increasing pressure due to its high environmental footprint and resource-intensive operations (Martínez et al., 2024). According to Vasileiou et al. (2022), the global manufacturing organization also faces some problems related to pursuing sustainable development by ensuring a circular economy. To address this, the concept of the circular economy (CE) has been established as a key model for redesigning resource use through waste minimization, extended product lifespan, and the regenerative reuse of materials (Zhu et al., 2013). In this study, Green Supply Chain Integration (GSCI) and Green Innovation (GI) have been recognized as strategic tools for organizations seeking to achieve circular performance while remaining competitive in global markets. This chapter illustrates a thorough background and motivation for the study, clear identification of problem statements, objectives of the thesis, and formation of research questions and hypothesis.

## 1.1 Background and Motivation

GSCI refers to the harmonization of environment-related activities through the supply chain, whereas GI refers to the innovation and actualization of novel or significantly improved products, processes, or practices to reduce environmental impacts. Vasileiou et al. (2022) mentioned that Green Supply Chain Integration refers to the intentional integration of environmental issues in supply chain management, including procurement, production, distribution, and reverse logistics. Green Innovation, by contrast, deals with designing and applying new or improved processes, products, or practices that reduce the environmental impact and increase sustainability (Singh & Ordoñez, 2016). Martínez et al. (2024) also argued that green innovation behavior has already begun to help organization to improve the balance between traditional business practices and green development. Although both have been studied extensively, they are typically treated

individually. But the synergy of GSCI and GI offers a unique platform to drive circular economy imperatives synergistically. In particular, the strategic alignment between GSCI and GI — the degree to which their goals and procedures complement one another — can affect the extent to which manufacturing firms are able to adopt circular practices such as recycling, product life extension, and resource efficiency.

The circular economy promotes maintaining the resources in use for as long as possible that are needed to enable the loop among supply chains (Zhu et al., 2013). With this, according to Singh & Ordoñez (2016), GI complements CE since it gives the possibility of creating products as recyclable ones, utilizing materials that are biodegradable in nature, and cleaner production mechanisms. There is evidence that businesses that embed green practices throughout their supply chain and invest in green innovation are best positioned to transition to sustainable performance (Le et al., 2022). The motivation behind this research is the increased need for empirical knowledge of how Finnish manufacturing firms are leveraging the intersection of green supply chain strategies and innovation to enable circular economy goals. Finally, the study offers a timely and practical look at how firms can integrate sustainability into their business by aligning GSCI and GI. Implications of the results are expected to guide managers in decision-making and help develop frameworks for enhancing circular economic performance via green strategy alignment.

## **1.2 Problem Statement and Research Questions**

This thesis seeks to bridge the literature gap by analyzing the strategic congruence between the GSCI and GI objectives and their joint impact on CE performance of Finnish manufacturing industry. While previous research has established the significance of green practices in fostering sustainability, there have been limited efforts towards empirically testing the contribution of their congruence in circular economy success at the firm level (De Jesus & Mendonça, 2018). The following Table 1 provides a summary of

current research studies, suggesting research gaps found and offering future research directions.

**Table 1:** Recent Studies on GSCI, GI, and Circular Economy – Research Gaps and Future Directions

Study (Author & Year)	Focus Areas	Identified Gap	Future Research Opportunity
Zhang et al. (2022)	They focus on Green Supply Chain Integration (GSCI), agility of Supply Chain and Green Innovation (GI) in Chinese manufacturing	The study Context-specific to China; lacks strategic fit and circular economy (CE) outcome emphasis.	Investigate GSCI–GI strategic alignment in developed economies such as Finland and its CE performance effects.
Mehmood et al. (2024)	Impact of GSCM on GI, environmental performance, and competitive advantage	Analyzes individual effects; does not quantify the interaction (strategic fit) between GSCI and GI.	Analyze how strategic alignment between GSCI and GI leads to CE outcomes within a developed country setting.
Martínez et al. (2024)	GSCM, circular economy capability, green ambidexterity	Absorbs the Spanish food and beverage industry; lacks structural modeling for strategic fit.	Assign strategic fit analysis to Finnish manufacturing with structural frameworks.
Hubarieva & Trushkina (2024)	Supply chain transformation via Industry 4.0 and CE principles	Focuses on digital technologies and closed-loop systems but without firm-level alignment insights.	Assess how digital transformation facilitates strategic alignment between GSCI and GI during CE transition.
Ruippo et al. (2023)	Innovation motivations and sustainability in Finnish packaging industry	Industry-specific; does not take GSCI–GI alignment or supply chain mechanisms into account.	Extrapolate the findings to broader manufacturing sectors and incorporate supply chain integration dynamics.

While Green Supply Chain Integration (GSCI) and Green Innovation (GI) are each, in their own respect, major enablers of circular economy performance, strategic alignment—the degree to which they are purposely orchestrated—remains to be explored. Prior research is prone to assessing either factor separately, with minimal knowledge of the degree to which co-fitness between them creates improved resource use efficiency, waste reduction, recycling behavior, and product life extension in factory settings (de Jesus & Mendonça; 2018; Zhu et al., 2013). Furthermore, few empirical studies on organizational-level strategic decisions—especially in Finnish manufacturing sector—exist to

drive circular change. This is unexpected given Finland's leading environmental policies and societal sustainability culture. It is crucial to understand how GSCI and GI strategically align and under what conditions this alignment happens to realize circular economic performance in practice.

The following research questions have been developed to address the issues outlined above:

RQ1: How does Green Supply Chain Integration (GSCI) affect Finnish Manufacturing industry's green innovation?

RQ2: How does strategic fit between GSCI and GI impact circular economy performance—especially in terms of resource use efficiency, waste minimization, recycling, and product life extension?

RQ3: What institutional factors in Finland moderate the relationship between GSCI, GI, and circular economy performance?

### **1.3 Research Objectives**

The objectives of this thesis are to develop a strategic model that creates an integration between Green Supply Chain Integration (GSCI) and Green Innovation (GI) for confirming circular economy performance in Finland's manufacturing industry. For achieving industrial sustainability, this study seeks to determine how GSCI and GI strategic fit can contribute to circular economy by adopting Triple Bottom Line Theory (TBL). By using quantitative methods, it will be used to measure the impact and build alignment, supported by fact-based data from a focused Finnish manufacturing organization where Organizational and contextual factors will both be examined to ensure that results are useful, relevant, and grounded in the industrial setting of Finland.

The study aims are outlined below:

**Objective 1: To identify the relationship between Green Supply Chain Integration (GSCI) and circular economy practices.**

This thesis starts by hypothesizing GSCI as a potentiality of organizational resources that allows companies to align the supply chain management behaviors with sustainability goals. GSCI will be analyzed based on three dimensions: internal integration, supplier integration, and customer integration (Yang et al., 2024). The first objective is to identify the relationship between GSCI and the circular economy.

**Objective 2: To design Green Supply Chain Integration (GSCI) as a green dynamic capability and analyze its effect on green innovation.**

After that, the contribution each of these dimensions contributes to green innovation (exploratory and exploitative innovation)—will be analyzed to determine the degree to which GSCI drives environmental innovation capabilities. In this stage of the research establishes the foundational link between green supply chain practices and innovation, identifying how external and internal integration collectively stimulate green innovation behaviors within manufacturing operations in Finnish manufacturing industry.

**Objective 3: To investigate the influence of different dimensions of green innovation (GI) (exploratory and exploitative) on circular economy among concepts based on sustainable development.**

After developing and taking the result of the Objective 1, this stage evaluates the level to which both exploratory (radical, future-looking) and exploitative (incremental, present-focused) green innovations contribute to CE outcomes. By breaking down innovation into two parts, the study will expose how different innovation strategies work to gain environmental and operational sustainability, which align with the TBL's three pillars.

**Objective 4: To adopt the Resource–Behavior–Performance (RBP) model for examining the relationships between GSCI (resource), GI (behavior), and circular economy (performance), including mediation analysis.**

To achieving the third objectives, this study employs the model which assesses the magnitude of GSCI, and green innovation as a capability, impacting CE performance. By addressing the above objectives, this study will contribute to the emerging literature on circular economy strategy by providing a structured, empirically tested model for aligning supply chain and innovation functions.

## **1.4 Scope and Limitation**

The aim and interest of this thesis are investigating the strategic alignment of GSCI and GI and how those are influence the CE performances within the Finnish Manufacturing Industry. A quantitative research design is used for analyzing and optimizing primary data from a structured questionnaire survey among a sample Finnish manufacturing companies. The focus of this thesis is first examining the three basic aspects of GSCI, then exploring the two types of green innovation behavior, thirdly assessing CE performance against the important indicators organization performance and finally employing Structural Equation Modeling (SEM) to verify the posited relations and mediation effects between GSCI, GI, and CE outcomes. While the study contributes to the knowledge of how strategic alignment between GI and GSCI affects the circularity of manufacturing, there are some limitations that affect this thesis.

### **1.4.1 Time Limitation**

There is a specific time frame for the master thesis, which limits scope to extensive work and deeper knowledge in this research. In data collection processes, time constraints make some difficulties for iterative survey design.

### **1.4.2 Distribution and Response Rate**

The survey was a distributed questionnaire using a non-probability convenience sampling approach among Finnish manufacturing companies via the Webropol system. Due to the nature of online distribution and the limited availability of targeted respondents,

the response rate was relatively low. It was challenging to reach and identify suitable participants in respective managerial roles, which may have influenced the diversity and richness of the answers.

### **1.4.3 Sample Size and Generalizability**

To run the Structural Equation Modeling (SEM), a large sample size is required to offer robust statistical analysis and ensure

reliable the outcomes and generalizability. As a result of the limited and slow response rate, the outcomes may not be indicative of the broader Finnish manufacturing industry. Future research could enhance scope by introducing qualitative interviews, larger sample sizes, and industry-specific studies for greater generalizability and applied purpose.

### **1.4.4 Exclusion of Qualitative Insights**

This research is restricted to quantitative data analysis, but for more quality assurance, qualitative methods, such as interviews or case studies, could also be adopted. For gaining the deeper insight into organizational strategies, cultural contexts, or barriers to GSCI–GI alignment, mixed methods could create more value.

## **1.5 Structure of the Thesis**

This thesis comprises the five major chapters that form part of the systematic research on the strategic fit between Green Supply Chain Integration (GSCI) and Green Innovation (GI) and how they impact Circular Economy (CE) performance in the Finnish manufacturing industry. Below is a comprehensive discussion of each part:

### **Chapter 1: Introduction**

The introduction and motivation for the study are given in the first chapter. The problem statement, research gap, and research questions are explained. The scope and limitation

of the thesis are discussed to determine its edges and methodology boundaries. Finally, this chapter offers the overall framework of the thesis.

### **Chapter 2: Literature Review**

This chapter is a presentation of summaries of pertinent theoretical and empirical literature informing the research framework. The chapter is initiated with the fundamental concepts of Supply Chain Management (SCM), then followed by an in-depth explanation of Green Supply Chain Integration, Green Innovation, and Circular Economy. Included are certain sub-sections such as the elements and forms of GSCI (Green Supplier Integration, Green Customer Integration, and Green Internal Integration) and different forms of GI (exploratory and exploitative). The chapter also includes a short description of Circular Economy with dimension and Integration of GSC and GI with Circular Economy practices. Lastly, to fit the study conceptually, it develops theoretical underpinnings like Strategic Fit with the Triple Bottom Line theory.

### **Chapter 3: Methodology**

In this Chapter, details of research design, methodology, and data analysis procedure are discussed that was used in the study. It outlines the research strategy followed, quantitative methods, data collection methods employing both primary (a questionnaire survey) and secondary (different journal, article & website) sources, and for data analysis using Structural Equation Modeling (SEM) in SmartPLSs software. Finally, Validity and reliability tests for research instruments which are also examined to ensure methodological sufficiency.

### **Chapter 4: Results and Discussion**

The results and discussion are based on the survey respondents which includes demographic analysis and hypothesis testing using SEM. For testing and model fit, this thesis employed SmartPLS 4.4 software. After getting the result, all findings that are discussed in the context of research questions, literature, and theoretical framework to draw pertinent conclusions.

**Chapter 5: Conclusion and Future Research**

The final chapter offers the overall conclusion of the research and evaluates research findings against the original research objectives. It outlines the theoretical contribution by the research and provides guidance for industry practitioners. The chapter ends by making comments on the research limitations and suggested future research directions.

## 2 Literature Review

This chapter includes the past and current studies of green supply chain integration, green innovation and circular economy and build a conceptual framework how green supply chain integration influences circular economy directly or indirectly where green innovation worked as a mediator. The purpose of this review is to find a strategic fit that informs a model which enhancing the sustainable performance in Finnish manufacturing industry. With this knowledge, it allows us to provide detailed analysis from an industrial point of view for future development of circularity practices.

### 2.1 Supply Chain

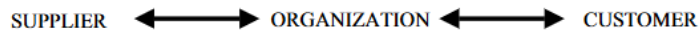
Due to the involvement of digital technologies and global interdependencies, the term "supply chain" has become increasingly important in recent decades in the business world. Traditionally, the supply chain worked as a simple task where manufacturers collected raw materials, transformed them into finished goods, and shipped them to the final consumer. According to Beamon (1998), the supply chain is a formal system that involves only two parts: transforming raw materials into finished goods and sending them to the final customer through shipment. It's also referred to the stages-by-stages activities which emphasized the procurement and final delivery to the customer (Tecc.com.au, 2002; Bridgefield Group, 2006).

Conversely, the understanding of definition of supply chain recently updating and integrating technology which was mentioned different research work, like as Ricárdez-Estrada et al. (2024) research, they found themselves that the Internet of Things (IoT), blockchain and artificial intelligence (AI) to improve the decision-making process and firster production with sustainability issues and alignments with stakeholders' goals of industry which called digital supply chain vision. To improve the supply chain relationships and outcomes, digital capabilities not only change the quality of service but also redesign the shape of supply chain structures.

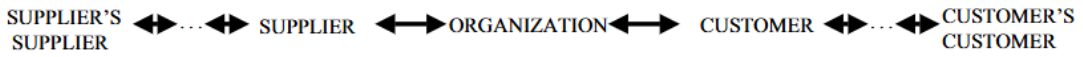
The supply chains have also integrated with some more sophisticated and self-governing arrangements, and ASCs coordinate physical, financial, and information flows to facilitate the flexibility of unavoidable environmental issues. According to Xu et al. (2023), “Autonomous supply chain (ASC) refers to a supply chain system that powers automation and data-driven technologies to perceive and respond to disruptions in real time.” This system manages with minimal or some events no human intervention with adapting and resilience in more volatile surroundings. According to Sharma et al. (2025) and Wieland and Durach (2021) that the concept of circular supply chain refers to the system which focuses on product lives, waste minimizing, and constructing assessment by recycling and reusing. Moreover, these systems also introduce the sustainability of the supply chain in the current world demand.

According to Little (1999); Chow and Heaver (1999), the intricate interdependence among the various partners within the supply chain systems includes their earlier definitions like distributors, manufacturers, suppliers, and logistics providers. These definitions laid the groundwork for conceptualizing the supply chain as a complex web rather than a mere linear progression. Mentzer et al. (2001) mentioned three types of supply chain where a direct supply chain comprises a firm, its immediate supplier, and its end customer and this system are engaged in the flow of goods, and services, with upstream and downstream directions. The second type is an extended supply chain that encompasses the suppliers of those suppliers and the customers of those customers. Conversely, an ultimate supply chain incorporates all entities engaged in the upstream and downstream movement of goods, services, finance, and information. Interestingly, as Mentzer et al. (2001) pointed out, supply chains also exist apart from their deliberate management. Even if none of the companies involved formally apply supply chain management principles, the supply chain nevertheless functions as a business fact. Figure 1 shows the picture of all types of suppliers, as mentioned by Mentzer et al. (2001).

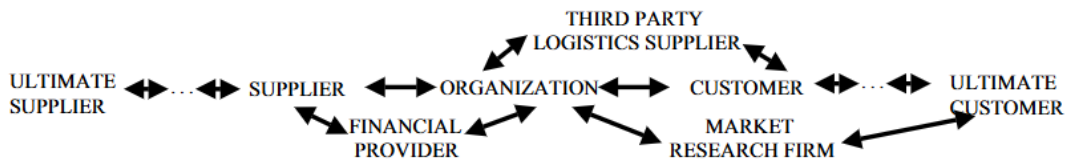
**TYPES OF CHANNEL RELATIONSHIPS**



**FIGURE 1a - DIRECT SUPPLY CHAIN**



**FIGURE 1b - EXTENDED SUPPLY CHAIN**



**Figure 1:** Types of Suppliers (Mentzer et al., 2001, p.5)

Contemporary scholarships continue this system’s perspective by emphasizing organizational commitment and strategic alignment. Lee et al. (2024) also introduced Supply Chain Orientation (SCO) as the strategic way that any company recognizes as a need to manage end-to-end flows effectively. Supply Chain Management (SCM), in this context, involves deliberate coordination of material, information, and financial flows among companies to streamline long-term value.



**Figure 2:** Flow of Supply Chain

In brief, Figure 2 shows the supply chain of today is no longer merely a logistics function but a strategic, where all the parties involve an entities network and digitally empower each other’s. It involves dynamic coordination, resilience, and continuous adjustment to internal and external pressures. From self-directed technologies to circular economy

principles, supply chains now demonstrate a holistic and forward-looking vision involving efficiency, ethics, and innovation.

## **2.2 Supply Chain Management**

Supply Chain Management (SCM) is now a central theme in research and business practice in recent decades. The early prominence of SCM's importance can be measured by how often SCM would be spoken about in the circles of logistics and operations. SCM is broadly defined as aligning business operations within and across firms for better long-term performance (Christopher, 2016; Cooper, Lambert, & Pagh, 1997). According to Swanson et al. (2018), Supply Chain Management (SCM) has emerged as the central theme in research and business practice over the past few decades. The early realization of the importance of SCM could be measured from the rate at which SCM would be brought up in the network of operations and logistics and observed the dramatic rise in talks about SCM during the mid-1990s (Cooper et al., 1997), pointing to its growing stature as an element of business scheme.

Strategically, SCM involves the coming together of two or more firms in alliances, trust, sharing of information, and long-term collaboration as cardinal pillars (La Londe & Masters, 1994; Chopra & Meindl, 2019). Chopra et al. (2007) differentiated SCM from conventional materials management by highlighting its systematic and strategic character and the emphasis on inventory as the last resort and not the initial buffer. Stevens (1989) delineated the notion of Supply Chain Management (SCM) as the synchronization of customer demand with the material flow, while concurrently striving to minimize expenses, enhance customer satisfaction, and sustain minimal inventory levels. Jones and Riley (1985) further redefined it as coordinating the entire material flow from suppliers through end users, which concurs with more contemporary conceptualizations of bringing SCM into a broad value chain network (Mentzer et al., 2001; Ivanov & Dolgui, 2022).

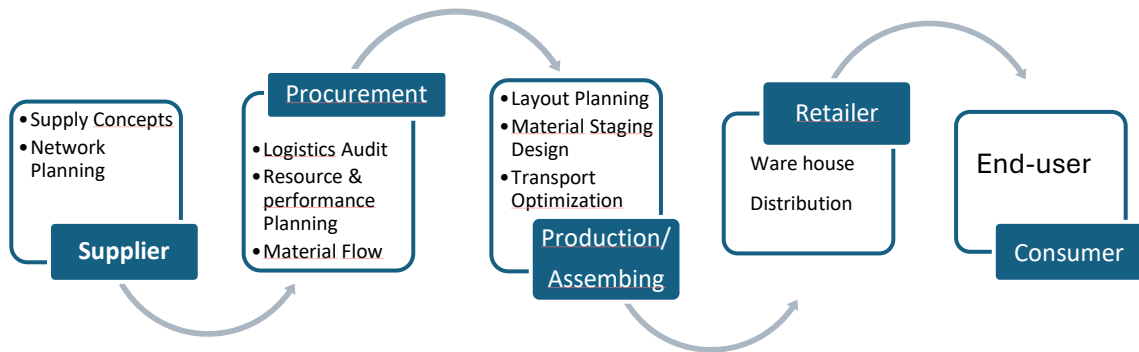
The SCM philosophy is to view the entire chain as a single entity, promoting a systems view rather than fragmented functional silos (Ellram & Cooper, 1990). The integrated vision appeals to best practice for modern integrated supply chains where there is an emphasis on the sharing of information in real time, flexibility, and resilience (Handfield et al., 2020). Langley et al. (1992) argue that customer satisfaction must be the underlying impetus for all SCM activities. Therefore, supply chains must be built to create tailored, specific value propositions.

Cooper et al. (1997) outline three fundamental characteristics of SCM as a philosophy:

1. A systems perspective on the management of the flow of goods from suppliers to end customers.
2. Strategic coordination of intra- and inter-firm activities.
3. An intense focus on customer value creation.

Effective SCM is dependent on a set of coordinated practices. These include integrated behavior, information sharing, shared risk and reward, goal congruence, process integration, collaboration, and long-term partnership (Tyndall et al., 1998). Among these, information sharing is especially important for reducing uncertainty and for enhancing performance across the chain (Salcedo & Grackin, 2000).

A four-stage SCM integration model, moving from internal functional silos to total supply chain cooperation with suppliers and customers. Each step is more complex and value-creating opportunities, and the final one is complete integration.



**Figure 3:** Supply chain Management

Figure 3 explains the building long-term relationships is another mainstay of SCM where so many activities deal with the whole SCM system. Effective partnerships are not only founded on trust and communication but also on cultural compatibility and shared objectives (Gentry & Vellenga, 1996; Lassar & Zinn, 1995). Strategic partnerships established through SCM construct competitive strengths by optimizing performance along the entire chain rather than companies in isolation.

Besides, Lambert, Stock, and Ellram (1998) promoted process-based implementation of SCM. This involves transforming conventional functions into cross-functional processes such as demand management, procurement, manufacturing flow, order fulfillment, and customer service. The shift from a function-based to a process-based framework enhances responsiveness and customer orientation.

In summary, modern SCM is the strategic and tactical alignment of business processes within and across companies with the primary goal of providing optimal customer value for least cost. This convergence transcends the logistics, manufacturing, finance, IT, and customer service functions. Modern SCM goes beyond cost reduction but also resilience, sustainability, and responsiveness in the face of amplified global uncertainties (Ivanov & Dolgui, 2020; Brandon-Jones et al., 2022). In Table 2, this study tries to show a clear picture on key construct of SCM and types of contribution from the early definition.

**Table 2:** Early definition of SCM

No.	Author(s) & Year	Core topics of research Title	Key Contribution to SCM	Type of Contribution
1.	Ross D.F. (1998)	Competing Through Supply Chain Management	Defines SCM as a systems philosophy for creating customer value and competitiveness through synchronization of firm capabilities	Conceptual Perspective
2.	Gentry and Vellenga (1996)	Fundamentals of Logistics Management	Describes open information sharing (e.g., inventory levels, forecasts) as key to reducing uncertainty in SCM	Empirical Insight
3.	Andel (1997)	<i>Transportation and Distribution</i>	Highlights the importance of sharing strategic and tactical data among supply chain partners	Practical Insight
4.	Beamon (1998)	Logistics and Information Technology: A Coordination Perspective	Discuss the impact of real-time information on supply chain performance	Operational Strategy
5.	Langley et al. (1995); Bask & Juga (2001)	Creating Logistics Customer Value	Support for process integration and frequent information exchange in the SCM implementation	Conceptual/Process Model
6.	Salcedo & Grackin (2000)	<i>Supply Chain Management Review</i>	Propose the "e-value chain" to describe digital supply chain coordination	Digital SCM Concept
7.	Manrodt, Holcomb, & Thompson (1997)	What's missing in Supply Chain Management?	Discuss cross-functional teams and third-party providers for SCM integration	Integration Mechanism

Literature review establishes that supply chain management (SCM) entails the involvement of several firms and different related business operations. The key purpose of such coordination is to enhance the long-run efficiency and effectiveness of individual participating companies as well as the supply chain. These must be effectively coordinated in not a single firm as well as across the entire network of supply chains. SCM is usually recognized to be the systematic and strategic coordination of traditional business processes and linked strategies, not only within a single firm but also among cooperative firms.

### 2.3 Green Supply Chain Management

The Green Supply Chain Management (GSCM) philosophy, also referred to as Environmentally Friendly Supply Chains (ECSC) or Environmental Supply Chains (ESC), was first introduced by the Manufacturing Research Institute at Michigan State University in 1996 (Awan et al., 2022). It emerged at a time when a growing worldwide movement for environmental protection and sustainable utilization of resources was gaining traction (Wang et al., 2021). Early definitions formed the basis for incorporating environmental concerns into traditional supply chain concepts.

GSCM worked as a set of management activities (Seman, 2018) and controlled as an action that ensures environmental sustainability through production, procurement and distribution (Chiou et al., 2011). Literature in the early 2000s extended GSCM's use beyond buying. According to Huang & Li (2017), all functions of supply chain are now integrated with environmental thinking and linked GSCM with environmental management with traditional SCM. However, Reverse logistics (RL) introduced by Zhu and Sarkis (2004) mentioned that it refers to a key component of GSCM which means goods movement from the consumer point to the point of the origin of the production.

Monczka et al. (2015) explained that it is imperative to implement GSCM practices along the value chain since educating consumers to reduce environmental impacts broadens the scope from internal operation to the whole chain. Waste reduction, as highlighted by Wang et al. (2021), also complement this shift by promoting less toxic waste creation during manufacturing and subsequent disposal phases. Shi et al. (2012) identify Green Supply Chain Management in two dimensions, one is life-cycle-oriented strategy and others is recommended product design which purpose is to attain highest level of environmental benefits and support firms for long terms sustainable development. Also, Wang (2014) described GSCM as high-tech management mode that integrates green manufacturing and supply chain technology for reducing wastes and time. For improving resource efficiency and negative impact of environment, Jensen et al. (2013) highlighted the multi-stake holder's involvement in SCM like supplier, distributors and consumer.

Same issues highlight Wang (2014) in his research, mentioned that by adopting life cycle assessment (LCA) approaches, GSC management have influenced the development of green logistics practices that are holistic.

Yisa and Taiwen (2022) provided a systematic explanation of the evolutionary process of GSC, basing its beginnings on the concurrent evolution of environmental policy and supply chain management practice. Laosirihongthong et al. (2013) provided empirical support, showing that firms are now more likely to evaluate the environmental performance of suppliers and request environmentally sound practices throughout the supply chain. So, it summarizes that the early research of GSCM established the concept and operational foundation and the latest literature addressing digitalization, customer perception, green design including waste reduction, and reverse logistics for reducing environmental harmless and creating strategic business value.

## **2.4 Supply Chain Integration**

One of the earliest concepts in the literature of Supply Chain Integration (SCI) is offered by Lambert et al. (1998), who characterizes supply chain management (SCM) as the "integration of business processes." Around the same time, Croom et al. (2000) emphasized that integration is a driving force for enhancing corporation as well as supply chain performance. Here the concept of supply chain integration is discussed into four different categories.

### **2.4.1 Early Conceptualizations and Frameworks**

Croom et al. (2000) have classified various definitions of SCM and SCI, ranging from descriptive purchasing to more comprehensive and transcendental ones. Such works had already realized that though the definitions were varied, integration was the thread that

ran through all. Harland et al. (2004) noted that SCI questionnaires produced a wide range of dissimilar constructs and measures, although each study typically focused on a few of them. This concurs with Zhang et al. (2015), who observed inconsistency in defining and measuring SCI.

#### **2.4.2 Evolution Towards Strategic and External Integration**

Putnik et al. (2005) proposed replacing traditional vertical integration with "virtual integration" where each of the partners does only its core competence. To achieve this purpose Garrocho et al. (2020) suggested in their study how any industries transformed vertically into horizontal integration, especially running business in high clock speed environment. Harland (1996) saw a shift towards vertical disintegration in most industries, while Bask and Juga (2001) proposed semi-integrated SCM models as opposed to total integration. Harland et al. (2001) suggested supply network dynamics and focal firm impact on environment and Bagchi and Skjoett-Larsen (2003) verified the same with contingency theory.

#### **2.4.3 Dimensions and Types of Integration**

Fawcett and Magnan (2002) mentioned that incorporating the strategic and operational affiliation with value chain, supply chain integration (SCI) treated as a multidimensional concept, and they also provided one of the foundational categorizations of SCI which divided into 4 general types of integrations. The first one is internal, which refers also to cross-functional integration, that means organization emphasizes coordination within the company among different departments like procurement, production, logistics, and marketing where ensure that the goals and processes of organization are always aligned. The second is backward integration with first-tier suppliers, here organization focuses on improving information sharing, jointly problem solving and production planning with the collaboration of upstream partners. The third dimension is forward integration with first-

tier customers, where firms work closely with downstream associates to better understand the demand of customers, to adapting improved delivery systems, and co-develop resolutions. Finally, Fawcett and Magnan (2002) identified full integration, that refers to extending the relationship with the suppliers to supplier, suppliers to customer's, the customers to consumer, creating end-to-end visibility and collaboration across the entire supply chain network.

According to Du et al. (2018) that effective SCI demands more than ordinary structural linkages between partners but needs to develop a higher level of alignment. They emphasized that for successful integration, it needs to complete tasks with strategic fit together and maintain the work coherence with empathetic among partners. This would mean that SCI extends beyond connecting different entities across the supply chain but also deals with creating shared visions, congruent practices, and mutual trust that enable collaborative value creation. Linking Fawcett and Magnan's (2002) structural typology with Du et al.'s (2018) interpersonal perspective, SCI would thus be an overarching theory that covers the physical and relational magnitude of supply-chain direction.

#### **2.4.4 Empirical Insights and Performance Outcomes**

Frohlich and Westbrook (2001), Ramdas and Spekman (2000), and Bagchi and Skjoett-Larsen (2005) emphasized both upstream and downstream integration. Flynn et al. (2010) and Zhang et al. (2015) described SCI as intra- and inter-organizational collaborative management of physical, informational, and financial flows for optimization. Chan and Qi (2003) and Cox (2004) duplicated this, defining SCM as the proactive coordination of the primary business processes across the entire supply chain and identified coordination of failures and uncertainties as main obstacles to effective SCI.

According to Shou et al. (2022), Supply chain Integration categorized into two dimensions - internal which refers to the integration of logistics and other activities and external means customers and supplier practices (Crenna et al., 2018). Flynn et al. (2010)

corroborated the evidence that for achieving a high degree of operational and business performance, particularly in internal, supplier and customer domains, SCI plays a positive role in achieving the goals.

## **2.5 Green Supply Chain Integration**

For sustainable professional practices, the business world is concerned with the Green Supply Chain Integration (GSCI) day by day. Existing literature classifies a few core elements of GSCI, such as green procurement (Fabbe-costes et al., 2008), green manufacturing, green logistics (Kawai et al. 2018), that mostly highlights the ingredients of environmental issues. The common goal of those components is to enhance sustainability with operational performance and focus on GSCI is essential for paramount to achieving environmental sustainability though the initial costs are high and complex the applications of practices.

Han and Huo (2020) mentioned in their study that GSCI is treated as the most important factors to confirm green supply chain management practices in any industry. In this approach, it is important to not only consider external integration but also internal integration. This involves developing the concept of operational efficiency and strategic effectiveness. GSCI encourages collaborations between organizations and their suppliers through a central operational strategy (Wong et al. (2015). Yisa and Taiwen (2022) categorize the green supply chain into three parts as internal, supplier and customer integration. According to Mousavi et al. (2018), for ensuring the dynamic capacity of those three integrations, it's better to understand the customer needs, technological support, transportation systems, and internal business strengths for any manufacturer to identify the business opportunities also (Lai et al. 2015).

To achieve the organization's highest level of growth and success, manufacturers make the optimal decision about their green projects with the integration of internal and external resources. Wong et al. (2015). GSCI also supports strategic and green innovation,

which permits the organization to share and minimize the environmental risks and take the responsibility to achieve the sustainability goal and it also ensures the organizational performance since it aligns both internal and external processes (Zhou and Li, 2020).

Yang et al. (2024) identified three basic factors of dynamic capabilities in green supply chain management based on green characteristics. They highlight in their research that green dynamic capabilities have three components, which are:

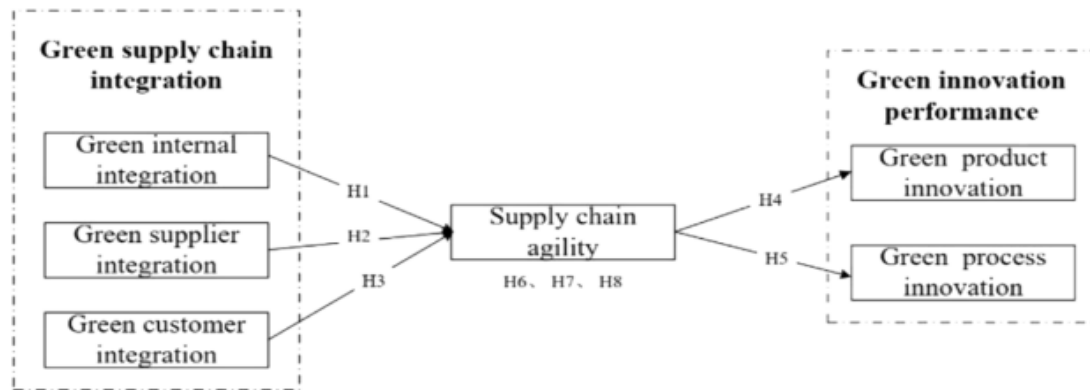
- Green Supply Integration (GSI),
- Green Customer Integration (GCI), and
- Green Internal Integration (GII).

They noted that those components helped GSCI achieve effective competitive advantages. According to Song and Swink (2009), green internal integration functions as a concept of the degree of connection, coordination, and information-sharing strategy that ensures the improvement of departmental activities to achieve green innovation. They also defined Green Internal Integration, Yang et al. (2024) mentioned in their article that it refers to the internal ability and strengths of an organization to share departmental information with others and collaborate smoothly to achieve green development goals. They also define green customer integration (GCI) and green supplier integration (GSI) in their research, where both of terms are used as the ability to manufacture that can develop strategies and policies for environmental cooperation with their main supplier and customers by sharing information, collaboration, and strategic agreements. According to Chen and Liu (2023), GCI refers to manufacturers' integration with the key customers for green innovation, and conversely, GSI refers to the degree of manufacturer integration with their main suppliers for green innovation.

The role of customers and suppliers is essential to developing any green innovation as mentioned by Melander (2017) and he also specified in his research how information, knowledge and capabilities are shared for the highest outcomes. Huang & Li (2017) said that the performance or outcomes depend on an organization's different stocks of

resources and capabilities. To enhance green innovation performance, most companies are progressively relying on external collaborators such as suppliers and customers to access beneficial capabilities and resources (Oinonen & Jalkala, 2015; Zhang & Li, 2010) that would be expensive to develop internally. It helps them to reduce learning and implementation problems. According to Feng and Wang (2016); Luo et al. (2010), the involvement of supply chain partners in green innovation can be beneficial, it may also boost coordination costs and hence require careful consideration. While Johnsen (2009) also said that when firms have high internal integration, it can better process, interpret, and utilize external knowledge, and therefore, learn from their partners. Effective internal communication and coordination improves a firm's ability to take advantage of green collaboration with suppliers and customers (Takeishi, 2001). Thus, internal integration not only enhances the capacity of a firm to absorb external inputs but also complements and magnifies the favorable effects of external green integration on innovation performance. Du et al. (2018) research work, which is mentioned in their conclusion, is that green customer and supplier integration play a very important role in the outcomes of green innovation, where internal integration enhances the effect of customer integration on innovation.

As a framework, GSCI allows companies to assign, coordinate and utilize the main resources needed for an environmental strategy. When an enterprise's environmental strategy is coupled with the GSCI mechanism, it will assist the business in fulfilling its strategic objectives and improve its environmental performance (Li et al., 2020). From the above discussion, Figure 4 clearly displays the whole green supply chain integration with green innovation. According to Zhang et al. (2022), all the hypotheses were accepted in their study.



**Figure 4:** GSCI with GI (Zhang et al. 2022, p. 07)

## 2.6 Green Innovation

Green innovation is a strategic process that refers to creating and using new products and services in a way that reduces environmental harmfulness and increases organizational performance by maintaining sustainability (Chen et al., 2006), and it includes different fields like energy efficiency, resource conservation, waste management, and the use of renewable energy. According to Klewitz & Hansen (2014), the main goal of green innovation is to create ecological balance, both technological innovations and non-technological innovations, by adopting processes and reducing emissions & energy consumption, thereby achieving cost savings. In addition, Borah et al. (2023) mentioned in their research that green innovation worked as a source of competitiveness where organizations can integrate sustainability with appealing environmentally conscious customers and relate with the green market. Interestingly, green innovation is likely to entail collaboration among multiple actors, including suppliers, customers, regulators, and research institutions; such collaboration enhances knowledge sharing, risk reduction, and the development of novel solutions to complex environmental issues (Rennings, 2000). So, green innovation is a multifaceted strategy that enables sustainable development, promoting friendly innovation and concerns not only compliance imperative but also a primary source of long-term competitiveness.

Yang et al. (2024) stated that the increase in studies on green innovation has brought about the focus on ambidextrous green innovation behavior, which involves balancing exploitative and exploratory green innovation (Sun & Sun, 2021). This classifies businesses to balance economic goals with ecological sustainability (Wang, 2014) and theory on ambidextrous innovation, this places green innovation about the novelty level. There are two dimensions of green innovation: exploitative green innovation and explorative green innovation.

### **2.6.1 Exploitative Green Innovation**

Wang et al. (2020) described exploitative green innovation as incremental improvement of current product, process or service to utilize resources more efficiently, improving existing technology and practices and it also applies to achieve resource efficiency improvement, waste avoidance, or environmental performance improvement without radical departures from current capabilities (Chen, 2014; Kortmann & Sebastian, 2021). Based on practical knowledge, these types of innovation involved less risk compared to others with low level investment (Jansen et al., 2013; Schamberger et al., 2013). Exploitative green innovation refers to the working process which reduces energy consumption and recycles material resources with exciting the process and incrementally changing the product design.

These are all oriented toward doing better for existing markets and customer bases with relatively predictable outcomes and shorter payback periods. They are very close to a firm's existing technological capacity, backing market position, improving cost bases, and maintaining environmental regulations. Current empirical studies show (Kortmann & Sebastian, 2021) that exploitative green investments have measurable short-term returns on environmental performance and financial performance and therefore become the preference of resource-effective firms (Santoyo & Azapagic, 2014).

But since it is based on existing knowledge, efforts like that are likely to fall short of the break-out potential to establish new markets for sustainability. Optimization-oriented efforts can drive diminishing returns and yield little in the form of strategic differentiation. For firms facing tight resource constraints or faced with high operational risk, exploitative green innovation offers a realistic, low-cost route toward environmental improvement (Sun & Sun 2021).

### **2.6.2 Exploratory Green Innovation**

Exploratory green innovation involves exploring and applying new environmental capacities, technologies, or knowledge beyond a firm's current horizon. Empirical research indicates that exploratory green projects are associated with long-term strategic performance and flexibility, which ensure higher organizational capability, structural flexibility, and integration of knowledge (Kortmann & Sebastian, 2021; Cheng, 2022). This innovation requires tacit and new knowledge sources that combine and entail greater uncertainty, risk, and investment, like technological exploration for the overall innovation literature (Business Finland, 2025). Another name of ERGI is radical innovations which introduce new business models that create new green market opportunities with a dynamic capability, for sustainable development in unpredictable environment (Bakos et al., 2020). Compared to EIGI approaches, ERGI aims to introduce new project with new technology to adopting new environment and addressing new consumer demand (Kortmann & Sebastian, 2021; Liu et al., 2025). But this strategy is risky—viz. high costs, ambiguous returns, and challenges in managing fuzzy innovation processes.

There are a few factors influencing green innovation that focus on various research work. These include external factors such as interest parties' pressure (Lin et al., 2014), rules and regulation of environmental challenges (Lin et al., 2016; Zhang et al., 2018), green supplier alliance systems (Chiou et al., 2011), knowledge of outward sources (Ben et al., 2018), and market demand (Lin et al., 2013). Additionally, some studies emphasize the internal factors that positive influences of green innovation and environmental ethics (Chang et al., 2011) & ecological orientation (Feng et al., 2018).

## 2.7 Circular Economy

Green supply chains always promote efficient use of resources while minimizing their environmental impact. In this context, the circular economy plays a crucial role by emphasizing designs that ensures minimum waste, utilizes materials effectively, and regenerates natural systems, replacing the traditional “take-make-dispose” model. According to Geissdoerfer et al. (2017), by implementing circular economy (CE) practices with high efficiency and low carbon emission can significantly enhance material usage. Ramakrishna et al. (2024) also mention that CE worked to achieve supply chain support global sustainability goals with promoting biodiversity. Bocken et al. (2016) believed that to reduce dependence on finite material and for achieving long term sustainability with economic benefits, now it is the time to switch foster and green innovation to different sectors like digital platforms, reverse logistics and "product-as-a-service" models. Therefore, the circular economy serves as both a sustainability imperative and an innovation catalyst in modern supply chain management.

Lewicka et al. (2023) and Viglioglia et al. (2021) emphasize that in a world where there are scarce resources, it is imperative to reuse and recycle in order to sustain future generations, this is why Stahel (2019) suggested the idea of a "closed-loop economy" to make product reuse, repair and remanufacturing possible and his study specifically dealt with the factors of product life that steered the current CE models and ensure industrial sustainability. For further development of this idea, Braungart and McDonough's book 'Cradle to Cradle' (2002) introduced new systems called “regenerative systems”, which eliminating waste (Mang & Reed, 2017). Hira et al. (2022) used a business model proposed by Gunter Pauli's “Blue Economy” (2010) for achieving zero waste by leveraging ecosystem services. These initial contributions turned CE into an interdisciplinary approach to sustainable economic development.

According to McCabe (2025), CE refers to a system that reduces material waste and environmental pollution, and Geissdoerfer et al. (2023) also focus on an end-of-life concept by reducing waste and facilitating systemic efficiency across the product lifecycle.

Newer frameworks ensure innovation, stakeholder involvement, and socio-technical systems for CE support (Ruippo et al., 2023). In this way, Circular economy introduces as a systemic transition—not only of products and processes—but also societal demand and governance institutions. Spani (2020) acquired leadership with the new circular economy action plan, which primally launched in 2015 and after that updated in 2020. The core aspect of EU strategy is involved sustainable product policy and framework, circular production, waste reduction, open innovation and recycling targets (Taušová et al., 2022).

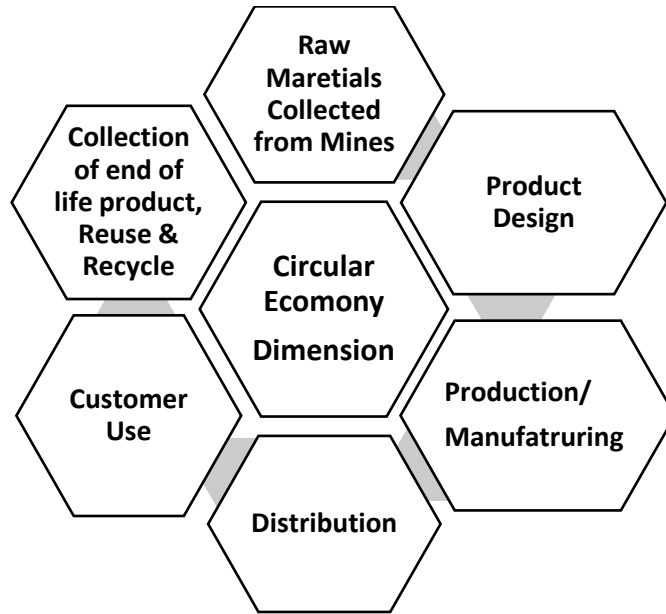
### **2.7.1 Dimension of Circular Economy**

Chen et al. (2025) identified a few strong drivers in their research for the successful implementation of a circular economy (CE). The three key dimensions of a circular economy are: lower customer cost, using recycled raw materials, and the development of energy-saving technology. They noted in their research that lower customer costs increase the reuse and recycling habits, which influences the choices of sustainable and green product designing and contributes to increasing the use of raw materials in building circular supply chain practices. Furthermore, developing energy-efficient technology significantly enhances resource efficiency and supports circular economic objectives (Chen et al. 2025).

Furthermore, Aloini et al. (2020) identified an overarching framework that emphasizes three primary pillars of a circular economy: environmental (decreasing pollution, preserving natural resources, waste reduction, closed-loop production and sustainable sourcing), social (promotes job creation, inclusive business models, employee training, and overall community welfare), and economic (financially viable, providing great incentives to shift away from the typical linear model).

In addition, Kumar and Kandpal (2025) stated that Industry 4.0 technologies are also emerging as enablers of the circular economy. In their research, they examined fifteen variables of relevance, and these technologies enhance waste tracing, harmonize

manufacturing processes, and track the product lifecycle, all of which are fundamental to enabling circular approaches. Finally, harvesting all these discoveries points towards a systems approach to building circular economies which demonstrated the following Figure 5.



**Figure 5:** Circular Economy Dimension

### 2.7.2 Integration of Green Supply Chain with Circular Economy

Green Supply Chain Management (GSCM) and Circular Economy (CE) are interrelated to each other and GSCM plays a significant role in propelling the strategies of CE, which ensure and concern all environmental issues of supply chain (Junejo et al. 2025). According to them, it involved all stages of supply chain, from sourcing to packing, transportation, and disposal of goods and services. Abdallah et al. (2024) also found in their studies that practices such as reusing material wealth, and reducing resources uses, recycling, and reverse logistics are constituted with the essential part of strategies circular economy. In the literature, it already mentions that circular economy concerns the environmental, social and economic for ensuring GSCM.

According to Boyer et al. (2021), for environmental matter, GSCM always gains the advantages of circular economy by minimizing waste, emissions, and raw material use

through eco-design and cleaner technologies and it also permits for reverse flows—product take-back and remanufacturing—hence closed-loop and cascading supply chains that extend the product lifecycle and reduce environmental burdens (Masudin et al., 2025). Socially, GSCM encourages relationship of cooperative stakeholders, inducing and enhancing environmental responsibility and knowledge sharing for sustainable practice. Specifically, it enables knowledge transfer, training employees for upskilling, and optimization of environmentally sustainable operation in all industries such as small and medium-sized enterprises (SMEs) in developing countries (Junejo et al., 2025). From an economic preceptive, it is cost-effective by creating new revenues through resale and reintegrating reused material. Since GSCM has positive impacts on efficiencies on production, it emphasizes CE by the sense of reducing energy and material costs. Additionally, it constructs corporate competitiveness by establishing more green markets, as well as improving overall firm performance based on sustainability-driven innovation (Kumar & Kandpal, 2025). In general, GSCM not only enables the transformation from linear to circular supply chains but also constructs the environmental, social, and economic pillars that support a successful circular economy.

### **2.7.3 Integration of Green Innovation with Circular Economy**

By reducing the impact on the environment and enhancing lifecycle performance, green innovation is a driver for Circular Economy (CE) growth, and it helps to implement the new approaches for products, services logistics and overall management (Masudin et al., 2025). The element of green innovation includes green product designs, cleaner production, sustainable service models, optimized logistics, and green management systems (Feng et al., 2018) and it exists all together with Green Supply Chain Management (GSCM) because GSCM operations are likely to stimulate innovation by means of joint ventures, green design approaches to products, and more environmentally friendly operating practices (Arfi et al., 2018). According to Lin et al. (2013), to enable the utilization of wealth and producing reduced waste in supply chain, green innovations are generally regarded

as essential drivers for superior CE performance. The Table 3 below shows the elements of circular economy which mostly integrated green innovation.

**Table 3:** Integration of Green Innovation with Circular Economy

Elements of CE	Integrations with Green Innovation
Environmental Factor	<p>According to Ameer et al. (2024), Green innovation enhances circularity in terms of greater resource efficiency, lower emissions, and enabling sustainable product lifecycles and it focuses on recyclability and durability, whereas process innovations minimize waste and pollution.</p> <p>Feng &amp; Chen (2018) mentioned that green logistics innovations optimize packaging and transport to reduce carbon footprints, and green service innovations such as sharing and maintenance platforms optimize product use and encourage reuse.</p>
Social Factor	Abdallah et al. (2024), Green innovation creates customer trust and brand value, that ensures and increases the stakeholder engagement and finds out the need for sustainable business models with responsible and inclusive design.
Economical Factor	Green innovation enhances operating efficiency by decreasing the raw material prices, and reduces level of energy consumption, generates access to new green markets, and offers protection against supply chain disruptions (Ameer et al., 2024). Moreover, it supports long-term competitiveness and differentiation by ensuring consistency with emerging sustainability of consumers and regulators' expectations.

Thus, green innovation is at the heart of embedding circular principles into modern industries, offering combined environmental, social, and economic value. So, after discussing the integration of GSCI and GI with Circular Economy, the following Table 4 illustrates the pathways which finally impact on circular economy in this study:

**Table 4:** Impact pathways

Particulars	Impact of Circular Economy		
	Environmental	Social	Economic
GSCM	Raw materials and other resources reduce, enhance supports systems of recycling, and ensure reverse logistics.	Increase collaboration & social awareness	Adopt Lower costs; creates new revenue portfolio.

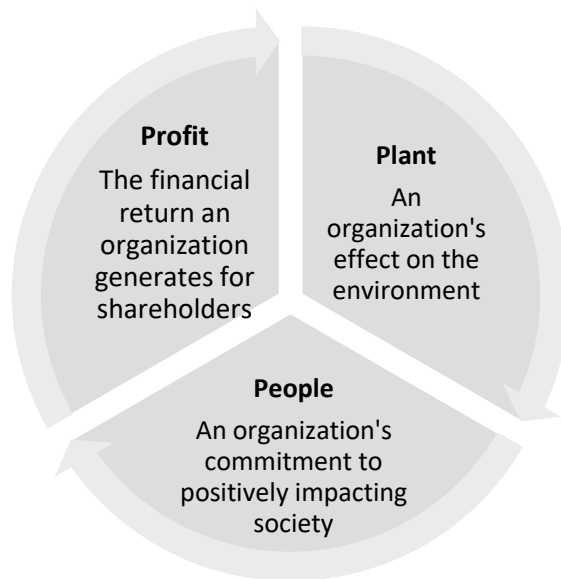
<b>Green Innovation</b>	Eco-designed products and services, introducing environmentally friendly cleaner processes, and optimized logistics.	Improves brand trust & stakeholder engagement.	Increases efficiency, effective competition, ensure market niche-opportunities.
<b>GSCM → GI → CE</b>	Enables innovations that amplify circular benefits.	Embeds sustainability across value chain	Improve profitability & resilience.

## 2.8 Integration of the Triple Bottom Line (TBL) Theory with the Circular Economy

In recent sustainability research fields, the most popular and merging issues are the Triple Bottom Line (TBL) and the Circular Economy (CE) which put emphasis on the fostering of resources efficiency with restorative and regenerative systems. It also aligns with the TBL strategy by promoting and creating value for environmental, economic, as well as social arenas (Elkington, 1998). But for long-term holism, one must explore further how CE activities mesh with all three TBL pillars, especially when applied in policy and organizational settings.

### 2.8.1 Theoretical Foundation of the TBL Theory

Triple Bottom Line (TBL) was originally debated in 1994 by John Elkington and more formally elaborated in his seminal 1997 work, *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. Figure 6 introduce Elkington (2004) TBL model which worked as an alternative paradigm to traditional financial accounting to a full indicator of organizational performance "People, Planet, Profit"—composing companies to reconcile care for social justice, environmental stewardship, and economic viability which treated as a pillar concept of sustainability in the early 2000s.



**Figure 6:** The 3 p's of Triple Bottom Line

Carter and Rogers (2008) extended the TBL original framework and combined the theoretical advantages with supply chain management that associate sustainability with sustainable competitive advantage. According to Santoyo-Castelazo & Azapagic, (2014), this TBL model is centered on environmental integrity, protection of ecosystems and prevention of emissions, resource use, and waste through proactive measures. Environmental issues normally follow economic in supply chain and sustainability resilience research, based on the challenge of balancing feasibility and sustainability goals (Tundys & Wiśniewski, 2023). Indicators are researched such as carbon footprint, reduction in pollution, eco-efficiency, and green product design.

In this TBL theory, the element of social dimension includes workforce practice, community citizenship, and equitable stakeholder interaction and incorporate the practices which able to measure not only the organization employee's contribution but also communities, and society as a whole—beyond humanitarian CSR. According to Carter and Rogers (2008), to increase competitive performance, the economic and social factors play a vital role. While the economic pillar is the most industrialized, the contemporary TBL construal focuses on sustainable profit with long term vision, comprising innovation,

risk management, and resilience. However, Carter and Rogers (2008) demonstrated that TBL-ranking the performance of organization is generally much better than those that focus on profit alone. Recent research such as Nogueira et al. (2024), confirms that TBL increases the firm's performance with the attachment of economic aspects and enabling sustainable practice with sound finances. Whereas TBL appears to be theoretically congruent, the application is usually inconstant. Ferrer-Serrano & Salesa (2025) mentioned that compared to others two aspect social dimension is poorly developed or unclear.

### **2.8.2 Economic Integration: Circularity as a Value Driver**

Circular Economy develop competitiveness by reducing material costs, unlocking secondary markets, and generating modernization by innovating business models (Van Bueren et al., 2023) and expansion to service-based revenue streams (e.g., product-as-a-service). Furthermore, some studies such as Santiago et al. (2025) discover that closed-loop circular production is the driving force behind green entrepreneurship and green innovation, which are best paired in production settings and supply chains. However, there are some constraints in the high initial investment and unclear long-term financial returns to adoption, especially by small and medium enterprises (SMEs) (Ferrer-Serrano & Salesa, 2025).

### **2.8.3 Environmental Integration: Closing the Loop**

As circular economy principles, environmental integration is closely interdependent with each other's and for design stability, modularity and recyclability this approaches directly address the climate change and resource depletion. For waste reduction purpose closing Loop worked well where circular economy helps to maintain carbon neutrality and ecosystem reinforcement (Blomsma & Tennant, 2020; Geissdoerfer et al., 2023) and it also creates robust demand with environmental incorporation of CE in the TBL (Zink & Geyer, 2017; D'Adamo et al., 2024). This is the complex pathway for sustainability issue but combining Triple Bottom Line theory with Circular Economy is a promising. Emerging

frameworks like eco-5HM and the CSR–CE–SSCM model offer structured solutions to this issue, but further empirical testing and development are required (Van et al., 2023).

#### **2.8.4 Social Integration: The Forgotten Pillar**

The last domain in this framework is the social domain where it identified the critical gap between integrating CE with the TBL. Prieto-Sandoval et al., (2021) mentioned in their research that the most important issues are sometimes overlooked in CE practices like labor market, community wellbeing, and equitable access to resources, frequently overlooked in CE writing and application proposals (Kopnina, 2019), although CE is hailed for creating employment in recycling and refurbishment businesses. Ferrer-Serrano and Salesa (2025) reported that lack of normalized indicators of social sustainability makes it challenging to measure it and it is advisable that there be a multidimensional framework that includes equity and justice in CE models.

### **2.9 Current practices of GSCI and GI with CE in Finnish Manufacturing Industry**

According to OECD (2025), the Finnish manufacturing industry currently works with green supply chain integration and green innovation which are closely related to circular economy objectives. Finland's policy context also explicitly connected with supply-chain circularity and industrial innovation. To achieve the goal of the carbon-neutral CE foundation by 2035, the Government's (2021) sets the direction as Strategic Programme for a Circular Economy, with lifecycle thinking, resource efficiency, and material circulation as mainstreamed organizing principles for businesses and their supply chains (Ministry of the Environment, 2024; Government of Finland, 2021). European reports corroborate the national viewpoint and certificate growing application of innovation funding to propel CE-based business models in Finland (EEA, 2024a, 2024b). For developing products with recyclability and durability, the close material loops and reverse logistics together makes more incentives for manufacturing and adding core GSCI practices enabling GI to

Together, these tools offer incentives for manufacturers to develop products for recyclability and durability, close material loops along tiers, and organize reverse logistics—core GSCI practices enabling GI to waterfall into measurable CE results (Business Finland, 2025a). For example, NEcOLEAP, led by Meyer Turku in shipbuilding, targets to develop a climate-neutral cruise ship concept by 2025 and carbon-neutral shipbuilding by 2030 which are totally ecosystem budget around €160 million and undertaken the evidence of supply-chain-wide converging on CE design and lifecycle management (Business Finland, 2025b; ZEM Ecosystem, 2025).

At the firm level, Valmet's "Beyond Circularity" (2022–2025) demonstrates OEMs hardwiring circularity into supply-chain operations and make an internal bridge with R&D for collaborative ecosystem that ensure to "transform waste and emissions into valuable resources,". In shipping, Husgafvel (2025) credentials how CE "10R" principles are being implemented, with ecosystem collaboration and supply-chain participation to appreciate circular design, repair and reuse—underlying GSCI–GI interaction in an exacting, and multi-tier industrial background. According to Sitra (2024), global and domestic initiatives agree with Finland's approach to using the ecosystem platforms for level up circular innovation in supply chains were highlighting the need to move beyond descriptive cases to metrics and tried models. Overall, Finnish practice during 2021–2025 is about (1) the policy supported the ecosystem integration (Veturi, mission-driven calls), (2) the corporate programs who are belong the high-profile, they incorporate circular design and secondary material flows into supply-chain functions (EEA, 2024a), and (3) biomaterial, GI that is based on GSCI with reverse logistics—although the area is still lacking in firm-level performance measures and SEM-type empirical tests to establish the strategic fit and effect sizes of GSCI-enabled GI on CE outcomes. (Business Finland, 2025a, 2025c; EEA, 2024; Ministry of the Environment, 2021; Valmet, 2022, 2024).

Despite clear evidence of positive behavior in green innovation and supply chain sustainability, there is a striking lack of empirical studies looking into the coordination of these practices as a strategic effort. To quantify the combined impacts of green capabilities and

activities on circular performance outcomes at the industry level, need to conduct research into the alignment of GSCI and GI and its impact on CE outcomes for Finnish manufacturing, with institution and context controls. The results of the present study are meant not only contribute to scholarly discussion but also to influence the real decision-making process of sustainability-oriented firms and policymakers.

## **2.10 Conceptual Framework of the Study**

According to Jabareen (2009), a conceptual framework is a complete guideline of research work that refers to systematic and rational representation of the key variables, concepts, and the connections among all the variables. However, a conceptual framework is also a theory defining how the research problem will be investigated and what is expected among the concepts to be researched (Tamene, 2016). Conceptual frameworks are mostly derived from existing theories, previous research, and the researcher's knowledge around study. In quantitative research, according to Adom et al., (2018), the conceptual framework is usually converted into measurable constructs and hypotheses, and it plays an important role in model building and statistical testing.

This study attempts to examine the strategic fit between Green Supply Chain Integration (GSCI) and Green Innovation (GI), and how strategic fit enhances Circular Economy (CE) practice within the manufacturing sector of Finland. The theoretical framework relies on the Triple Bottom Line (TBL) school of thought and positions itself under the Resource–Behavior–Performance (RBP) school of thought. Here Table 5 represents all classifications of variables used in the Conceptual framework:

**Table 5:** Classification of Variables Used in the Conceptual Framework

Category	Variable Name	Abbreviation	Type	Description
<b>Independent Variables</b> Yang, et al. (2024) Lee (2024), Zhu et al. (2013) and Kong et al. (2021)	Green Internal Integration	GII	Latent Variable	Integration of environmental practices within internal operations and processes.
	Green Supplier Integration	GSI		Collaboration with suppliers on green goals, processes, and information sharing.
	Green Customer Integration	GCI		Collaboration with customers on environmental performance and feedback.
<b>Mediator Variables</b> Yang, et al. (2024); and Wang et al. (2021).	Exploratory Green Innovation	ERGI	Latent Variable	Radical and novel green innovations for future capabilities.
	Exploitative Green Innovation	EIGI		Incremental innovations using existing knowledge and processes.
<b>Dependent Variable</b> (Li, & Lan, 2010)	Circular Economy Practices	CE	Latent Variable	Outcomes such as resource efficiency, waste reduction, recycling, and reuse.
<b>Conceptual Link</b> (Zajac et al., 2000)	Strategic Fit with Circular Economy	SFCE	Theoretical Concept	Indicates the alignment between green strategies and CE goals.
<b>Framework Basis</b> (Ferrer & Salesa., 2025)	Triple Bottom Line Dimensions	TBL	Theoretical Lens	Economic, environmental, and social sustainability dimensions.

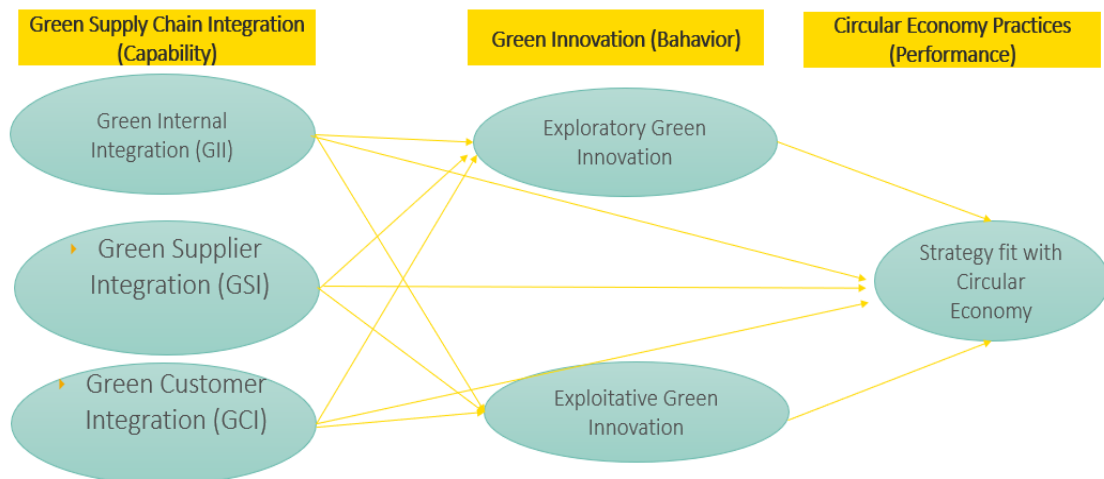
**Figure 7:** Conceptual Model

Figure 7 shows the conceptual model which is used in this study. The conceptual model is tested through Structural Equation Modeling (SEM), a quantitatively rigorous technique suitable for testing complex mediating relationships and for the measurement construct validation. The hypotheses set forth are to be tested empirically using a survey administered to Finnish manufacturing firms.

The following Table 6 shows the clear picture of proposed hypothesis which meets the study objectives sequentially:

**Table 6:** Proposed hypothesis

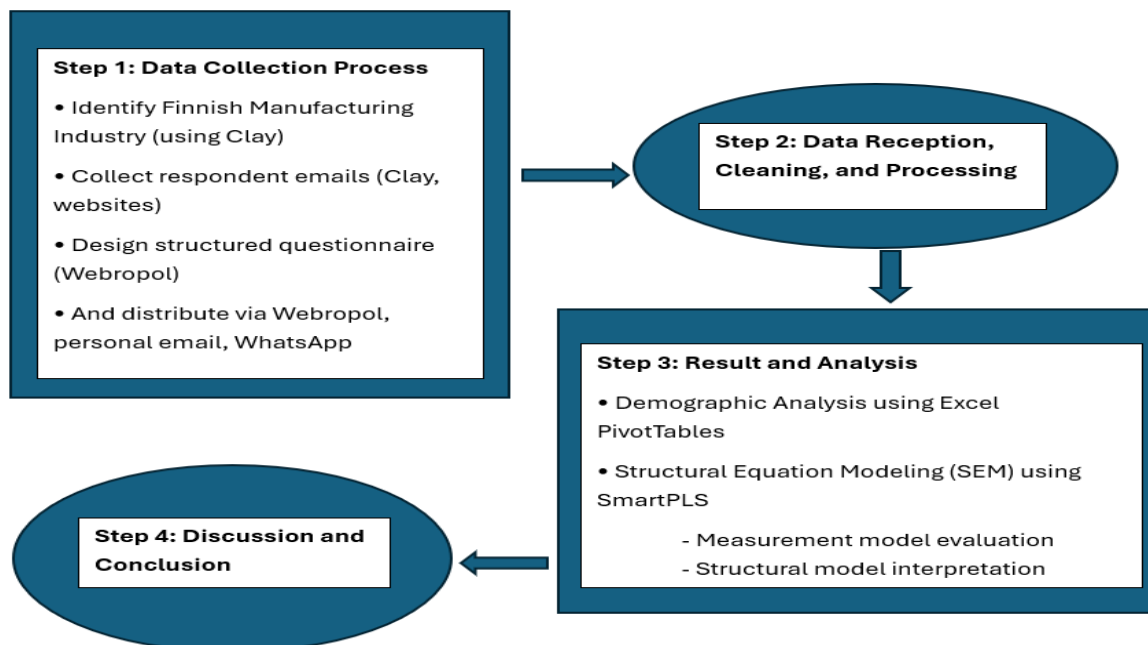
<b>Objective</b>	<b>Description of objective</b>	<b>Proposed Hypothesis</b>
<b>Objective 1</b>	To identify the relationship between Green Supply Chain Integration (GSCI) and circular economy practices.	<b>H1:</b> (a) GCI, (b) GSI and (c) GII are positively related to circular economy.
<b>Objective 2</b>	To design Green Supply Chain Integration (GSCI) as a green dynamic capability and analyze its effect on green innovation	<b>H2:</b> Green Customer Integration (GCI) is positively associated with (a) Exploratory Green Innovation and (b) Exploitative Green Innovation. <b>H3:</b> Green Supplier Integration (GSI) is positively associated with (a) Exploratory Green Innovation and (b) Exploitative Green Innovation. <b>H4:</b> Green Supplier Integration (GSI) is positively associated with (a) Exploratory Green Innovation and (b) Exploitative Green Innovation.
<b>Objective 3</b>	To investigate the influence of different dimensions of green innovation (GI) (exploratory and exploitative) on circular economy among concepts based on sustainable development.	<b>H5a:</b> ERGI is positively related to circular economy performance. <b>H5b:</b> EIGI has a positive association with circular economy performance.
<b>Objective 4</b>	To adopt the Resource–Behavior–Performance (RBP) model for examining the relationships between GSCI (resource), GI (behavior), and circular economy (performance), including mediation analysis.	<b>H6:</b> ERGI mediates the positive relationship between GSCI and CE performance. <b>H7:</b> EIGI is a mediator that works as positive relationship between GSCI and CE performance.

**Note:** Proposed Hypothesis 1, 2, 3, & 4 are collected from previous study Yang, et al. (2024) that support with this study objectives.

By addressing the above objectives and hypothesis, the findings aim to support Finnish manufacturers in making informed decisions that enhance both environmental and economic performance through strategic alignment of green initiatives.

### 3 Methodology

This methodology chapter outline the research method employed in exploring the strategic congruence between Green Supply Chain Integration (GSCI) and Green Innovation (GI) and their effect on Circular Economy (CE) performance in Finland's manufacturing industry. The chapter broadly discusses the study methodologies employed in the research steps-by-steps, like the research philosophy and approach, explains the research design, and details the data collection and analysis. It also further clarifies procedures of sampling, how to measure the variables, and software utilization by using the data. The method of research is quantitative, and it applied Structural Equation Modeling to verify hypothesis for the conceptual framework and thus confirming the assumed relationships. Finally, the chapter includes a discussion regarding the ethical implications and the limitations of the employed method, hence ensuring that the research process was transparent and academically credible. In figure 8, the methodological approach utilized in this thesis is shown.



**Figure 8:** Methodological approach

The research philosophy of this study relies on the positivist paradigm, which means the reality of the context does exist and is independent of the spectator, quantifiable, and impartial. Creswell & Creswell (2018) mentioned that positivism gives credibility to the use of systematic approaches and statistical analysis in hypothesis testing that is derived from general theory. For measurement this study used survey indicators and empirically examined their relationships with the help of models which is predominantly suitable to this study because it involves specification of operationalized constructs (such as GSCI, GI, and CE). The study employs a deductive approach which starts with pre-determined themes and data will be linked with this themes for reaching a certain decision (Elias, 2012). In this study, theoretical implications derived from the Triple Bottom Line (TBL) and link with the conceptual models.

The conceptual model is developed using established constructs from the literature, and the research tries to check empirically the cause–effect relations between them based on information gathered from Finnish manufacturing firms. The deductive approach ensures logical consistency among research questions, theory, and analytical approaches and therefore enhances the validity and reliability of the study. This study highlights the quantitative method and the application measured by statistical tools like PLS/SEM to find out the relationship among various variables where more than one latent construct mediating effect, which also makes it an extremely appropriate choice in terms of exploratory nature of this study.

### **3.1 Research Design**

This study applies a quantitative research design to investigate the strategic alignment of Green Supply Chain Integration (GSCI) and Green Innovation (GI) and their impact on Circular Economy (CE) performance in Finnish manufacturing industries. The design of the study is conceptualized to test the hypothesized relationships among constructs systematically using structured survey data as well as through statistical modeling techniques. By adopting quantitative approach, it enables us to measure the crucial concepts

and testing hypotheses on quantified data. According to Saunders et al. (2019), the design helps to interpreting data by statistical inference which matches the study attempts to establish typical trends and correlations indicative of industry-level tendencies. The study is cross-sectional, i.e., data was collected once at a single time point. Although this design restricts the capacity to determine causality, it is adequate for evaluating relationships and mediating effects in a practical, time-limited master's thesis environment.

This study is also explanatory because, apart from describing current practices, it seeks to describe the effect of one variable (GSCI) on another variable (CE performance) with a mediating effect from another variable (GI). To achieve this, the research employs Structural Equation Modeling (SEM) using SmartPLS software, which is suitable for verifying complex models dealing with latent variables and mediating effects (Hair, 2014). The SEM approach also allows for testing of measurement validity and structural relationships, in accordance with the deductive research design used in this thesis. Combined, the quantitative, cross-sectional, and explanatory elements of the research design provide a definitive and methodologically sufficient structure for addressing the research questions and fulfilling the study objectives.

### **3.2 Population and Sampling**

The study population of interest to this investigation comprise organizations in the Finnish manufacturing industry that are involved or performing sustainable and circular economy operations. They are considered relevant since they have direct impacts on supply chain management, product innovation, and environmental performance—main elements of the constructs of Green Supply Chain Integration (GSCI), Green Innovation (GI), and Circular Economy (CE).

Owing to time and practical constraints of accessibility, the study employed the non-probability convenience sampling technique, where in this instance there was both purposive and convenience sampling. Employing business directories, and websites of

manufacturing companies, the study screened out initially a list of manufacturing companies active in Finland. The selection criteria for selecting firms were firms that are engaged in production and logistics operations and are most likely to engage in sustainability activities. The questionnaire was then distributed via e-mail using the Webropol tool for the respondents to fill in the questionnaire online.

49 usable answers were collected. This sample, though small, is considered adequate to handle in Partial Least Squares Structural Equation Modeling (PLS-SEM), a method known to provide good estimates even under small to medium sample sizes (Hair, 2014). Also, diversity in the sample with respect to company size, industry, and sustainability involvement enhances the population generalizability of results in the context of Finnish manufacturing.

It must be noted that respondent randomness in taking part was influenced by the voluntary nature of the survey and diminishing access to the aspired managerial roles. Despite a try to reach out to pertaining professionals, some barriers had to be overcome in identifying appropriate contacts and evoking a better response. The responses received are, however, sufficient for exploratory model testing and provide useful insights on prevailing industry practice. Respondent company characteristics, including size, industry, and respondent role, are also investigated in the demographic section of this research to provide context for the results and allow generalizability within limits.

### **3.3 Data Collection Methods**

To prepare data for empirical analysis, the study utilized both primary and secondary data sources. Both the consistency and reliability of the collected data were guaranteed through a systematic process and the backup of the quantitative nature of the research.

### **3.3.1 Primary Data Collection**

The primary data for this study were collected in an online Webropol questionnaire survey prepared and distributed through the Webropol system. The Webropol questionnaire survey was designed to gather data regarding the practice and perception of green supply chain activities, innovation behavior, and circular economy results within Finnish manufacturing industries.

The questionnaire comprised closed-ended questions framed based on a five-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree), as attached in appendix 1. This was for the sake of response ease, standardization, and statistical analysis friendliness, particularly in Structural Equation Modeling (SEM). The questionnaire items were borrowed from existing validated scales in the literature to ensure conceptual congruence with GSCI, GI (exploratory and exploitative), and CE constructs. The intended respondents were mostly departmental managers, operations managers, production or supply chain experts, marketing and sales officials within Finnish manufacturing companies. The questionnaire was sent by email, and sufficient time was provided for them to fill in the form. Responses in the form of 49 complete and valid responses were received and analyzed finally.

### **3.3.2 Secondary Data Collection**

This study used secondary data for literature review and developing conceptual frameworks from different sources like scholarly journals, government reports, industry newsletters and online textbooks. The sources also utilized different publication which are including publications of Finnish Ministry of the Environment, and OECD documents etc. The secondary data had various functions:

- To support the development of the conceptual framework and the literature review.
- To place the Finnish manufacturing sector in global CE practice.
- To obtain external validity and consolidate the quality of the research results.

All secondary sources were selected based on credibility, applicability, and publication within the last five years and some others previous years to ensure the research is recent and representative of developments and practices that have recently taken place.

### **3.4 Measurements**

The measurement items for each of the constructs were derived from known and tested scales and specifically adapted to the Finnish manufacturing sector's context for green supply chain management. The study utilizes the latent variable approach, under which each core construct is translated into several observable indicators which are quantified using a five-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree").

The construct of independent variables like Green Supply Chain Integration (GSCI) was calculated by 18 items which designed from various studies through Yang, et al. (2024), Lee (2024), and Zhu et al. (2013). On the other side, mediator variables Green Innovation (GI)—were allocated into exploratory and exploitative green innovation—was determined with 12 items (6 for each dimension), fabricating upon the backgrounds of Yang, et al. (2024), Jansen et al. (2006) and Wang et al. (2020). To evaluate depending variable Circular Economy, there were 6 items which were used to draw the result, sketch from the validated scales of Li & Lan, (2010). The latent variables of circular economy were established on the indicators used in OECD (2025) and Finnish environmental performance reports, aligned with the Triple Bottom Line (TBL) framework's environmental, economic and social dimensions. To regulate industry and organizational differences, organizational location, employee size, experience years of employees, existence of GSCI, GI and CE were considered control/contextual variables which are nominal measuring scales, and these variables were asked in the demographic section and used for enhancing the interpretation of the SEM results.

The relations among the constructions are modeled through Partial Least Squares Structural Equation Modeling (PLS-SEM). A confirmatory measurement model evaluation was

conducted prior to structural analysis through tests of internal consistency (Cronbach's alpha, composite reliability), convergent validity (Average Variance Extracted), and discriminant validity.

### **3.5 Data Analysis Methods**

This study employs a combination of descriptive statistics, and advanced multivariate analysis techniques to explore the investigated data and to test the conceptual model. Because of the complexity of the model and the intervening role of Green Innovation (GI), data analysis consisted of two stages: (1) demographic analysis and preprocessing data, and (2) hypothesis testing with Partial Least Squares Structural Equation Modeling (PLS-SEM).

#### **3.5.1 Demographic and Descriptive Analysis**

Data exploration and demographic profiling were initially conducted by using Excel Pivot Table and visualizing the data, and it provided insight into the distribution of company location, company size, respondent roles, respondent year of experience, organization types and engagement with GSCI, GI and circular economy practices. This descriptive analysis was used to create the sample context and to assess the response variability. It also confirmed that there were no missing values or outliers that could bias the subsequent structural model analysis.

#### **3.5.2 Measurement Model Assessment**

For achieving the result, this study used PLS- SEM which was judged using SmartPLS 4 software that ensure the constructs' reliability and validity within the study framework. According to Hair (2014), the value of Internal consistency reliability is equal to or greater than 0.70, which was evaluated using both Cronbach's Alpha and Composite Reliability (CR). And establishing the convergent validity, the Average Variance Extracted (AVE) for

each construct was examined, the range is minimum threshold of 0.50 deemed satisfactory. In addition, by using factor analysis, individual indicator loadings were analyzed, and items with loadings of 0.70 or above were retained, indicating strong contributions to their respective constructs for safeguarding that each construct was analytically distinct from the others in the model, discriminant validity was tested using the Fornell–Larcker criterion and cross-loadings.

### **3.5.3 Structural Model Evaluation**

Following the measurement model confirmatory test, the structural model was also tested to examine the hypothesized relationships between the key constructs and to assess the goodness of the model in general. Path coefficients ( $\beta$ ) were contrasted to determine direction and intensity of relationships between constructs such as Green Supply Chain Integration (GSCI), Green Innovation that includes Exploratory Green Innovation (ERGI) and Exploitative Green Innovation (EIGI), and Circular Economy (CE). For testing the statistical importance of path-coefficients, 5,000 bootstrapping resamples were employed calculate the mediating effects. The model's explanatory power was assessed with the coefficient of determination ( $R^2$ ), which is a measure of dependent variable variance explained by the independent variables over the total dependent variable variance. Effect size ( $f^2$ ) was also calculated to determine the relative influence of each independent construct on the dependent construct. Predictive significance ( $Q^2$ ) was assessed based on the blindfolding approach to confirm the capacity of the model in predicting observed values. Mediation analysis was also employed to analyze the indirect effects of GSCI on CE through the mediating roles of ERGI and EIGI to determine the ways in which green innovation is supposed to produce sustainable results.

### **3.5.4 Justification for SEM**

The use of Partial Least Squares Structural Equation Modeling (PLS-SEM) is justified in the current study since there are several methodological benefits. To begin with, PLS-

SEM tolerate small to moderate sample sizes. Second, it can handle both formative and reflective measurement models to meet the need of measuring complex latent variables such as GSCI, GI, and CE practices, here it is mentionable that all latent variables are proposed to be measured through multiple indicators using Likert-scale items in survey questionnaire. Third, PLS-SEM is best suited to exploratory research on new and emerging areas, the same being true when it comes to strategic fit between GSCI and GI in the Finnish manufacturing sector. Through usage of strategy, the study delivers rigorous proof of measurement validity as well as structural relations, presenting enough empirical ground for studying the effects of strategic fitness.

### **3.6 Ethical Considerations**

For confirming the Ethical principles, this study was strictly followed and ensured academic integrity and compliance with data protection regulations. Participants were up to date about the study's purpose, and they have the right to withdraw their opinion at any time without consequences. The survey questionnaire conducted by Webropol software (Webropol Finland research strictly adheres to GDPR compliant with the EU General Data Protection Regulation, GDPR), which respondents had to accept before continuing. For maintain confidentiality and privacy, the data sheet does not include any personal identifiers like respondent's name or company name, only collect some general information about organization size, area and respondent's responsibilities department. For academic honesty, keep properly referencing all secondary sources according to APA 7th edition. No plagiarism work was created, and the finished paper will be scanned for plagiarism using detection software before submission.

## **4 Results and Findings**

This chapter offers the empirical results of the quantitative analysis employed to examine the strategic fit between Green Supply Chain Integration (GSCI), Green Innovation (GI), and Circular Economy (CE) performance in the Finnish manufacturing industry. After collecting raw data from 49 participants across different functional areas and companies, the chapter starts with a demographic analysis were intended to find out the respondent profiles in the context of Finnish manufacturing industry and their involvement in green supply chain integration with circular economy. It then goes on to scrutinize the validity, reliability, and property of the measurement constructs, and estimate the structural model by employing Partial Least Squares Structural Equation Modeling (PLS-SEM). The chapter attests to the hypotheses presented systematically, including the direct and indirect effects to establish the mediating effect of green innovation.

### **4.1 Demographic Analysis**

To better understand respondents' background and the assessment of diversity of opinion reflected in this study, a demographic analysis was conducted. 49 valid responses were gathered from various professionals employed within the Finnish manufacturing industry. The findings are indicated below:

Respondents were drawn from multiple functional areas within their organizations, indicating a balanced representation across the operational spectrum. Table 7 shows that out of the 49 respondents participating in the survey, 20 were from the supply chain department, 12 and 10 respondents respectively from the marketing and HR & Admin department and only 7 respondents were from others department like accounting, finance and production departments.

**Table 7:** Department/ Area of Responsibility of respondents

Name of Departments	Number of participants
Accounting & Finance	4
HR & Admin	10
Marketing	12
Production	3
Supply Chain Management	20
<b>Grand Total</b>	<b>49</b>

Most of the companies are in Vaasa (18) and Helsinki (16), and rest of the participants companies (15) are in other areas such as Espoo, Oulu, Pietarsaari, Porvoo and Turku which are shows at below Table 8:

**Table 8:** Company Location

Company Location	% of Companies participant
Espoo	3
Helsinki	16
Oulu	5
Pietarsaari	2
Porvoo	1
Turku	4
Vaasa	18
<b>Grand Total</b>	<b>49</b>

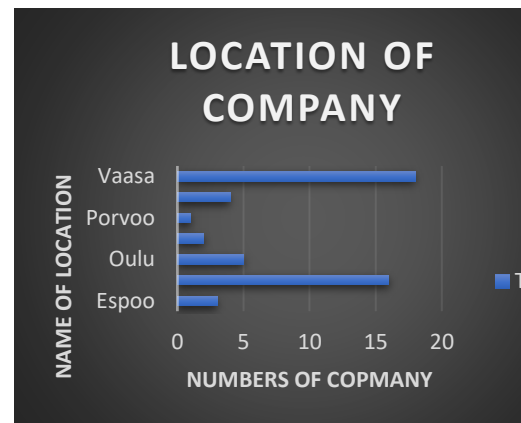
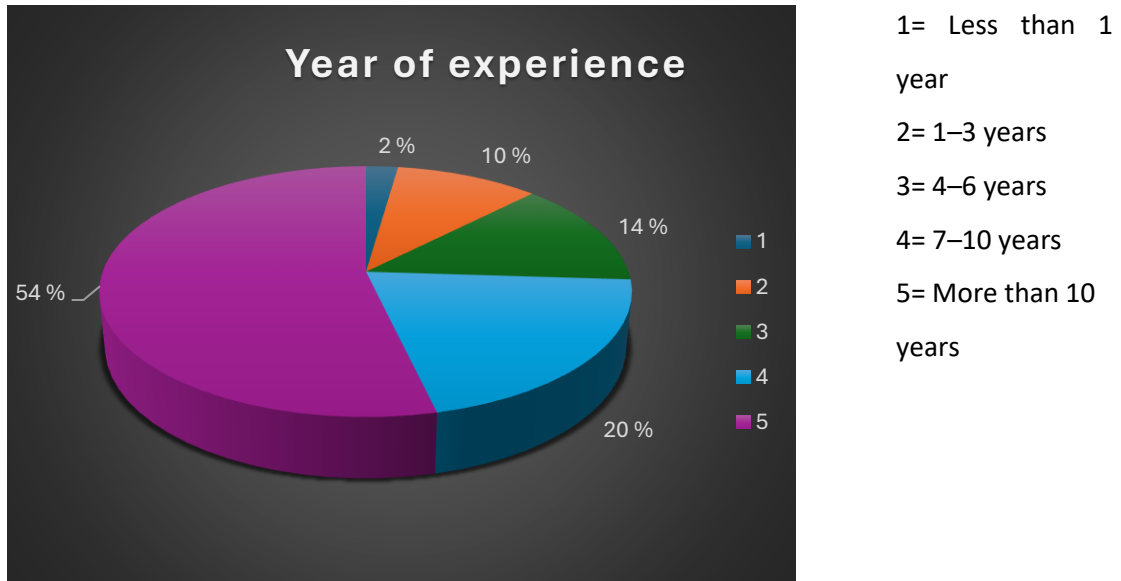
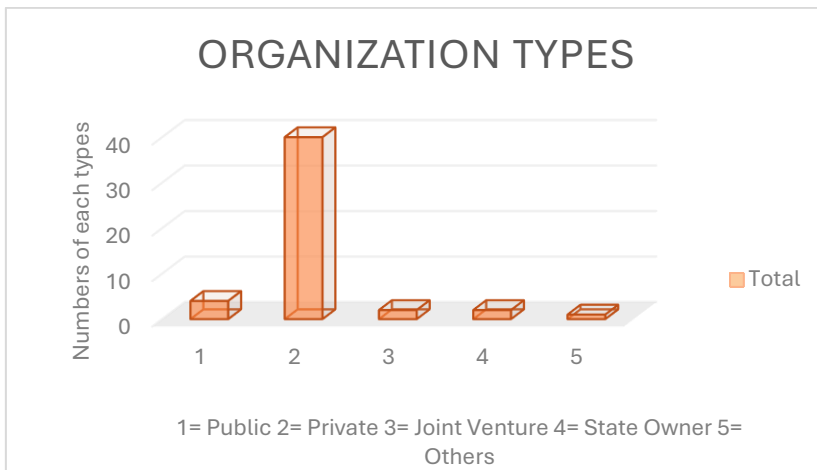


Figure 9 demonstrates the years' experience of each respondent, Considering the data sheet, 54% have more than 10 years' work experience in their respective fields, 20% have 7 to 10 years' experience, 24% have 1 to 6 years work experience and only 2% have less than 1 years' experience, which supports result of this study.



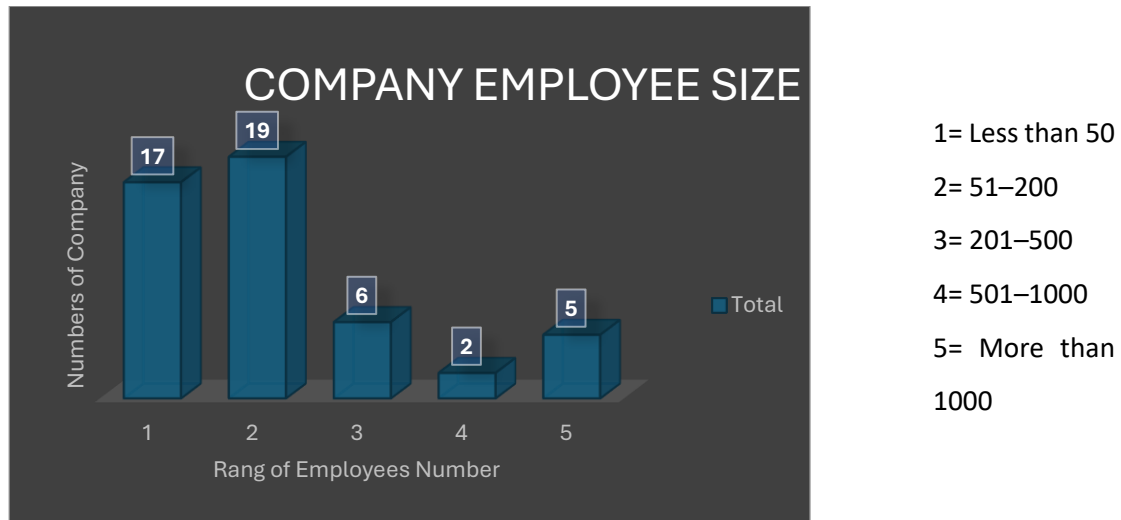
**Figure 9 :** Employee year of experience

For better understanding, this study collects information about the company types which mainly categorized in 5 different ways. Figure 10 below shows that there are 38 private companies' participants in this study and 4 are public and the rest of the 5 companies are operating a different form of the business (joint venture, state owner & others).



**Figure 10:** Types of Organization

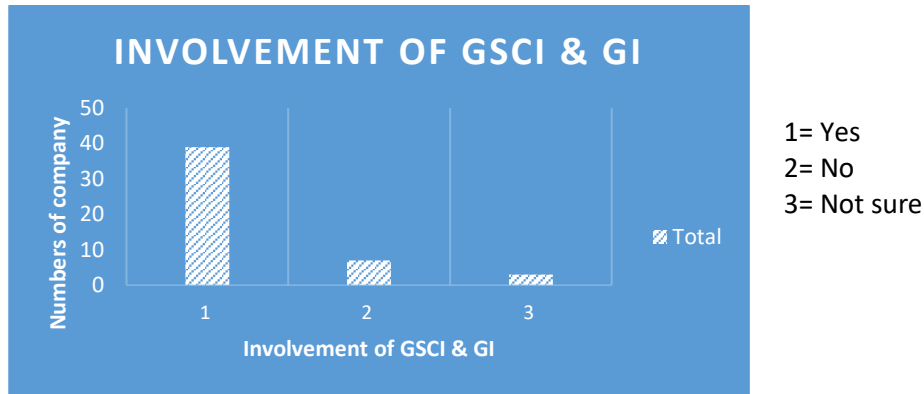
From the survey of the employees of each company, 17 companies have less than 50 employees, 19 companies have 51-200 employees, 6 have 201-500 employees and the rest of the 7 have 501-1000 employees, which presented in Figure 11 below.



**Figure 11:** Company's employees size

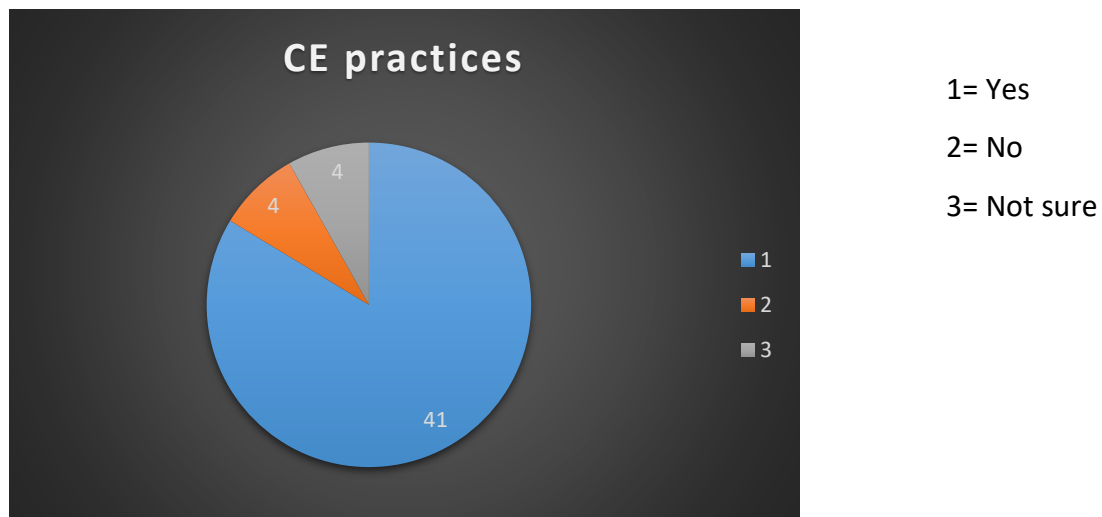
## 4.2 Companies involved in green supply chain, green innovation and circular economy

In this section, the aim is to collect feedback about the current involvement of the respondents in green supply chain, green innovation and circular economy. By unveiling the background of respondents about this, 39 respondents said that their company already practices green supply chain and green innovation in their operation, 7 respondents informed that they are not involved in their operation and only 3 respondents showed in Figure 12 that they are not sure about green supply chain, and green innovation.



**Figure 12:** Company involved in green innovation or green supply chain projects

Furthermore, Figure 13 using a scale 1= yes, 2= No, and 3= Not sure, the study examined the familiarity of the respondents with circular economy practices. As per survey, most of the respondents (41) are familiar with circular economy involvement and only 4 are not sure about it and the rest of respondents stated that their company is still not thinking about circular economy in their operations.



**Figure 13:** Circular Economy practices in operation

This demographic overview places the findings in context and ensures that opinions under analysis reflect diverse roles, level of experience, and company type across Finland's manufacturing industry.

### **4.3 Properties of measurement items**

In this study, the construct items of descriptive analysis are measured on the six constructs—Green Customer Integration (GCI), Green Supplier Integration (GSI), Green Internal Integration (GII), Exploratory Green Innovation (ERGI), Exploitative Green Innovation (EIGI), and Circular Economy (CE). These constructs bear broadly positive observations among the respondents in relation to green integration and innovation practices. In Table 9, the detailed data of all the properties are considered as variable.

#### **4.3.1 Green Supply Chain Integration (GCI)**

Green Customer Integration (GCI) responses are significantly positive, with mean values ranging from 4.02 to 4.204. Most items have medians of 4 and 5, indicating the respondents overwhelmingly endorsing GCI practices. Standard deviations of the order of 1 suggest moderate variation, and the negatively skewed values throughout (up to -1.521) suggest responses were clumped at the top end of the scale. The excess kurtosis varies from variable items where high positive kurtosis was observed (e.g., GCI3 = 2.007), suggesting peaked distributions. The Green Supplier Integration (GSI) notion exhibits relatively high mean values between 3.714 and 4.083, and medians mostly of 4. Moderate spread is evident in the standard deviations, although skewness values are negative, they are less pronounced compared to GCI, and kurtosis values are within normal range and indicate that the data is neither flat nor peaked. In general, GSI is preferred by the respondents, but the degree of agreement is less homogeneous than GCI.

**Table 9:** Properties of measurement items

<b>Construct</b>	<b>Item Code</b>	<b>Mean</b>	<b>Me- dian</b>	<b>Scale min</b>	<b>Scale max</b>	<b>Standard deviation</b>	<b>Excess kurtosis</b>	<b>Skew- ness</b>
Green Customer Integration (GCI)	<b>GCI1</b>	4,122	4	1	5	1,081	1,076	-1,252
	<b>GCI2</b>	4,163	5	1	5	1,076	1,357	-1,353
	<b>GCI3</b>	4,204	5	1	5	1,049	2,007	-1,521
	<b>GCI4</b>	4,122	4	2	5	0,94	-0,153	-0,863
	<b>GCI5</b>	4,122	4	1	5	1,043	0,339	-1,034
	<b>GCI6</b>	4,02	4	1	5	1,02	0,203	-0,876
Green Supplier In- tegration (GSI)	<b>GSI1</b>	4,02	4	1	5	1,02	1,49	-1,233
	<b>GSI2</b>	3,837	4	1	5	1,094	0,741	-1,013
	<b>GSI3</b>	3,939	4	1	5	0,998	0,16	-0,763
	<b>GSI4</b>	3,714	4	1	5	1,143	-0,552	-0,508
	<b>GSI5</b>	4,083	4	1	5	0,932	0,995	-0,969
	<b>GSI6</b>	3,939	4	1	5	1,077	0,356	-0,886
Green Internal In- tegration (GCI)	<b>GII1</b>	4,061	4	1	5	1,058	1,115	-1,194
	<b>GII2</b>	4,02	4	1	5	0,958	1,009	-1,048
	<b>GII3</b>	3,673	4	1	5	1,038	0,133	-0,652
	<b>GII4</b>	3,837	4	1	5	1,076	0,305	-0,88
	<b>GII5</b>	3,939	4	1	5	1,058	0,773	-1,049
	<b>GII6</b>	3,857	4	1	5	1,088	0,774	-0,981
Exploratory Green Innovation (ERGI)	<b>ERGI1</b>	3,592	4	1	5	1,123	-0,607	-0,371
	<b>ERGI2</b>	3,776	4	1	5	1,093	-0,667	-0,5
	<b>ERGI3</b>	3,633	4	1	5	1,155	0,081	-0,786
	<b>ERGI4</b>	3,755	4	1	5	1,134	0,599	-0,966
	<b>ERGI5</b>	3,694	4	1	5	1,146	-0,121	-0,705
	<b>ERGI6</b>	3,694	4	1	5	1,146	-0,121	-0,705
Exploitative Green Innovation (EIGI)	<b>EIGI1</b>	3,959	4	1	5	1,124	1,054	-1,251
	<b>EIGI2</b>	3,837	4	1	5	0,976	0,271	-0,745
	<b>EIGI3</b>	3,918	4	1	5	0,986	0,223	-0,753
	<b>EIGI4</b>	3,939	4	1	5	0,998	1,429	-1,144
	<b>EIGI5</b>	3,816	4	1	5	1,119	0,377	-0,885
	<b>EIGI6</b>	3,98	4	1	5	1,078	0,492	-0,966
Circular Economy (CE)	<b>CE1</b>	3,878	4	1	5	1,081	1,251	-1,248
	<b>CE2</b>	3,98	4	1	5	1,059	1,782	-1,34
	<b>CE3</b>	3,98	4	1	5	1,02	1,285	-1,149
	<b>CE4</b>	4,02	4	1	5	1,02	1,229	-1,114
	<b>CE5</b>	3,776	4	1	5	1,015	1,42	-1,094
	<b>CE6</b>	3,735	4	1	5	1,065	1,307	-1,114

In contrast, for Green Internal Integration (GII), mean scores range between 3.673 and 4.061, which indicates slightly more moderate or neutral agreement than in GCI and GSI. Medians are all 4, and the skewness is moderately to the left, the kurtosis values are close to normal or mildly positive, which indicate symmetrical response patterns. Overall, the results generally show that respondents tend to view internal integration positively but with further improvement or variation in internal green practices.

#### **4.3.2 Green Innovation**

From Table 9, the mean values of ERGI scores are lower, ranging from 3.592 to 3.776. And the median indicates the overall agreement (4 among items), but it is lower in comparison with integration interpretations. Standard deviations are slightly higher at 1.12, that shows greater variety of responses. The Skewness is less negative (between -0.371 and -0.966), and kurtosis is flat or slightly negative, indicating a spread of responses. This would indicate that the respondents are more polarized in their opinions regarding exploratory innovation activities, perhaps because they have had different interpretations or experiences of such efforts.

The Exploitative Green Innovation (EIGI) ratio indicates greater consensus than ERGI, with means from 3.816 to 3.98 and medians always 4. Standard deviations are of the order of moderate variation, and negative skewness values again are observed to lean towards high agreement. Kurtosis is positive but not unusual with a bit of concentration of the distribution around the mean. These inclinations articulate a more favorable and stable direction towards exploitative green innovation practice based on addressing the current systems in a positive manner rather than trying to find new ways.

#### **4.3.3 Circular Economy (CE)**

Table 9 also shows the mean values of Circular Economy (CE) products have a relatively good consensus, which vary between 3.735 and 4.02. The left-skewed (up to -1.34)

values indicate that many respondents used higher-scale responses. The result of Standard deviations is also moderate, and kurtosis values all above zero (up to 1.782), indicating pointed distributions with responses clustering at the higher scale end. This indicates widespread adoption of circular economic measures, which is a positive sign of acceptance of sustainability and resource efficiency operations by the respondents. Generally, the sample favors green practices in customer, supplier, internal operations, and innovation categories, with a high level of support for circular economic principles.

#### 4.4 Construct Reliability and Validity

Before testing the hypothesis, it was important to evaluate the reliability and validity of data. To determine the robustness of the measurement model, reliability and validity were evaluated using a set of critical measures: Cronbach's alpha, composite reliability ( $\rho_a$  and  $\rho_c$ ), and average variance extracted (AVE). The measures provide an estimate of internal consistency and convergent validity of the latent constructions in question which are given in the below Table 10.

**Table 10:** Construct Reliability and Validity

Particulars	Cronbach's alpha	Composite reliability( $\rho_a$ )	Composite reliability( $\rho_c$ )	Average Variance extracted (AVE)
CE	0.936	0.940	0.950	0.758
EIGI	0.955	0.956	0.964	0.817
ERGI	0.942	0.945	0.955	0.778
GCI	0.956	0.965	0.964	0.819
GII	0.934	0.942	0.949	0.757
GSI	0.953	0.959	0.963	0.811

All the constructs demonstrated satisfactory internal consistency reliability, as reflected in Cronbach's alpha coefficients ranging from 0.934 to 0.956. CE was 0.936, EIGI was 0.955, ERGI 0.942, GCI was 0.956, GII was 0.934, and GSI was 0.953. All of these are well above the recommended minimum of 0.70, meaning all the items used in measuring every construction are highly consistent (Hair et al., 2019).

Composite reliability was also calculated based on both  $\rho_a$  (rho\_A) and  $\rho_c$  (traditional composite reliability). The rho\_A estimates were all between 0.940 and 0.965, while rho\_c estimates ranged between 0.949 and 0.964. Both ranges are above the minimum requirement of 0.70, once more confirming the reliability of the constructs (Dijkstra & Henseler, 2015; Hair et al., 2019). This indicates that all constructions are measuring reliably the variance within their own respective indicators. Additionally, convergent validity was also checked via Average Variance Extracted (AVE), which assesses the extent to which each construction explains the variance of its indicators. AVE statistics for all the constructs were significantly higher than the commonly accepted cutoff of 0.50 (Fornell & Larcker, 1981) ranging from 0.757 (GII) to 0.819 (GCI).

These results support that an overwhelming amount of variance in the observed variables is explained by their corresponding underlying latent variables and therefore there are high levels of convergent validity. Cumulatively, these findings determine the measurement model to have high levels of reliability and validity. The high internal consistency and sufficient convergent validity ensure that the constructions used in this study are psychometrically sound. This strong foundation justifies a move to the structural model assessment in subsequent analyses.

#### **4.5 Structural Equation Modelling**

The outer Model analysis that results from SmartPLS execution offers an adequate testing of the reflective measurement model for this research which ensure the validity and reliability. Hair et al. (2021) states that loadings 0.70 and higher indicate reliable indicators and convergent validity. The constructs in the model all possess loadings 0.70 and higher, which is a testament to their respective indicator reliability.

Based on the data presented in Table 11, for Circular Economy (CE), loadings range from 0.834 to 0.900, and for Exploitative Green Innovation (EIGI) indicators, from 0.871 to

0.926—both reflecting high internal consistency. Additionally, the loading factor values of ERGI show even higher indicator loadings, between 0.843 and 0.952, for its reliability. Green Customer Innovation (GCI) has consistently high loadings (0.888–0.901) that these items meet the validity criteria, whereas Green Innovation Implementation (GII) shows satisfactory values of between 0.730 to 0.945. Although GII6 shows the lowest value of 0.730, it is nevertheless satisfactory. Such a value is satisfactory if, as maintained by Hair (2014), overall construct reliability is high. Finally, Green Supply Innovation (GSI) indicators have loadings between 0.877 and 0.990, reflecting the quality of measurement. In Appendix 2 also shows the outer loading value with mean, standard deviation, t-statistical and p-value of all latent variable in details for more justification. So, the overall result confirms that all items represent good construction for reliability and support a well specified measurement model and reinforcing convergent validity.

**Table 11:** Factor Loading (Validity Testing- SmartPLSs)

<b>Factor analysis- Outer Loadings Matrix</b>						
	<b>CE</b>	<b>EIGI</b>	<b>ERGI</b>	<b>GCI</b>	<b>GII</b>	<b>GSI</b>
<b>CE1</b>	0.887					
<b>CE2</b>	0.890					
<b>CE3</b>	0.876					
<b>CE4</b>	0.824					
<b>CE5</b>	0.845					
<b>CE6</b>	0.900					
<b>EIGI1</b>		0.919				
<b>EIGI2</b>		0.901				
<b>EIGI3</b>		0.926				
<b>EIGI4</b>		0.871				
<b>EIGI5</b>		0.902				
<b>EIGI6</b>		0.903				
<b>ERGI1</b>			0.844			
<b>ERGI2</b>			0.839			
<b>ERGI3</b>			0.952			
<b>ERGI4</b>			0.938			
<b>ERGI5</b>			0.843			
<b>ERGI6</b>			0.870			
<b>GCI1</b>				0.891		
<b>GCI2</b>				0.888		
<b>GCI3</b>				0.940		
<b>GCI4</b>				0.888		
<b>GCI5</b>				0.920		

Factor analysis- Outer Loadings Matrix						
GCI6				0.901		
GII1					0.859	
GII2					0.833	
GII3					0.919	
GII4					0.946	
GII5					0.915	
GII6					0.730	
GSI1						0.930
GSI2						0.877
GSI3						0.918
GSI4						0.881
GSI5						0.909
GSI6						0.888

The correlation matrix in Table 12 illustrates the correlations between the six latent constructs—Circular Economy (CE), Exploratory Green Innovation (EIGI), Exploitative Green Innovation (ERGI), Green Customer Integration (GCI), Green Internal Integration (GII), and Green Supplier Integration (GSI). Hair et al. (2021) indicate that correlation values close to +1.0 indicate strong positive correlations, while values below 0.85 are largely desirable to establish discriminant validity based on the Fornell–Larcker criterion.

**Table 12:** Latent Variables - Correlations

Latent Variables correlations						
	CE	EIGI	ERGI	GCI	GII	GSI
CE	1	0.867	0.812	0.581	0.732	0.635
EIGI	0.867	1	0.867	0.595	0.820	0.708
ERGI	0.812	0.867	1	0.562	0.753	0.642
GCI	0.581	0.595	0.562	1	0.526	0.696
GII	0.732	0.820	0.753	0.526	1	0.685
GSI	0.635	0.708	0.642	0.696	0.685	1

The results indicate strong positive correlations among several constructs. CE is extremely highly correlated with EIGI (0.867) and ERGI (0.812), suggesting that circular economy initiatives are strongly aligned with both exploratory and exploitative green innovation practices. The two types of green innovation (EIGI and ERGI) are also strongly correlated (0.867), suggesting conceptual closeness for strategies innovation.

The relation between CE and GII (0.732) shows moderate-to-high correlations, and this tendency also shows in between EIGI and GII (0.820), that means indicating innovation efforts have strong relationships with implementation outcomes. Correlations with GCI are generally moderate, the strongest being with GSI (0.696).

Overall, while all relationships are positive and substantial, some scores (e.g., CE–EIGI, EIGI–ERGI) approach the 0.85 threshold, requiring further investigation of discriminant validity via HTMT to determine construct distinctiveness.

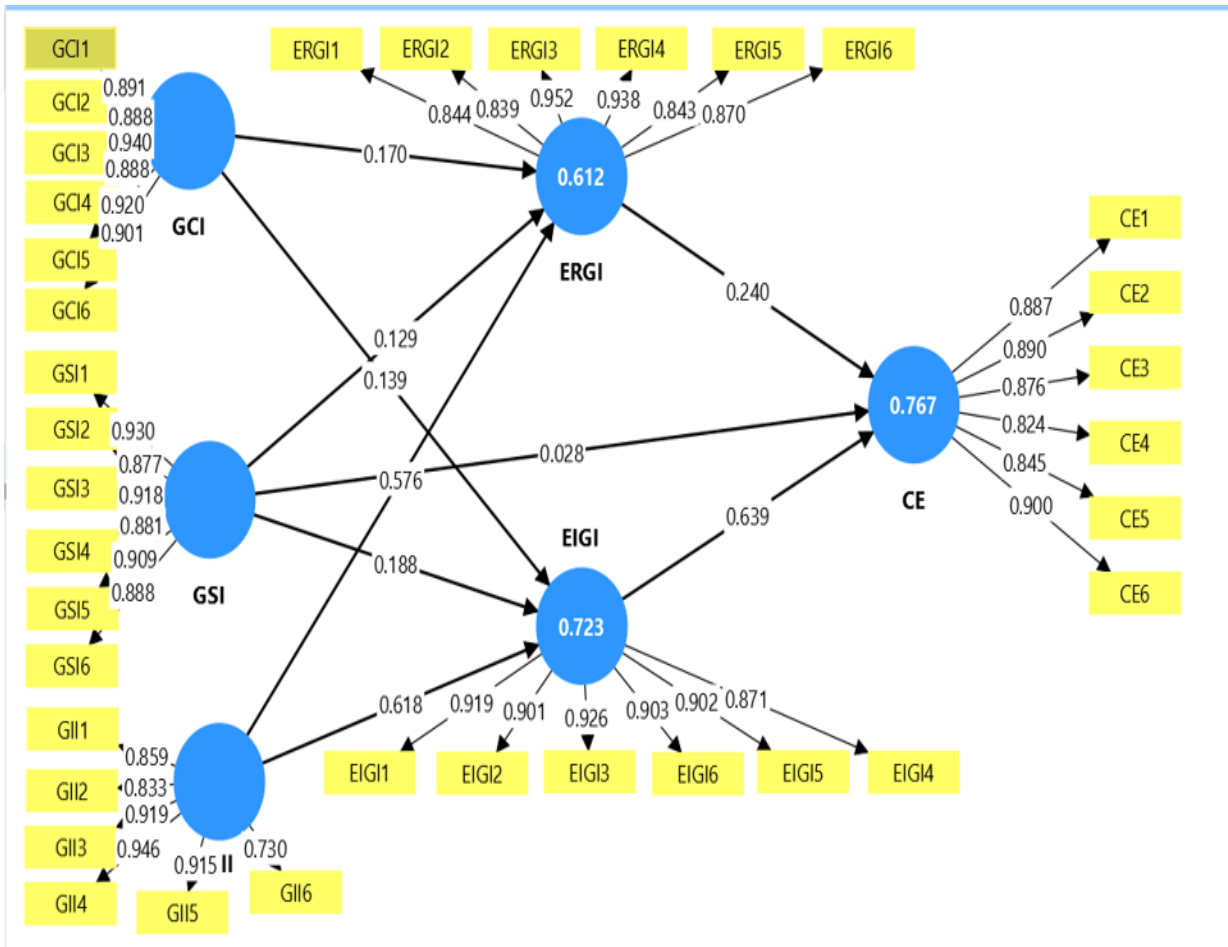
Discriminant validity of the data set constructs was analyzed following the Fornell-Larcker criterion. According to Fornell & Larcker (1981), this method necessitates that the square root of each construct's Average Variance Extracted (AVE) recorded on the diagonal of the correlation matrix should be greater than its relationships with any other constructs (off-diagonal values). In the Table 13, represented that the square root of AVE for each construct—CE (0.871), EIGI (0.904), ERGI (0.882), GCI (0.905), GII (0.870), and GSI (0.901)—is higher than the respective inter-construct correlations. For example, CE has a square root of AVE of 0.871, which is higher than its correlation with each of the other constructs (e.g., EIGI = 0.867, ERGI = 0.812). This is true for each construct. Therefore, based on the Fornell-Larcker criterion, all the constructs have adequate discriminant validity, which implies that each construct is empirically distinct from the other constructs in the model.

**Table 13:** Discriminant validity- Fornell Larcker Criterion (SmartPLSs)

Discriminant validity- Fornell Larcker Criterion						
	CE	EIGI	ERGI	GCI	GII	GSI
CE	0.871					
EIGI	0.867	0.904				
ERGI	0.812	0.867	0.882			
GCI	0.581	0.595	0.562	0.905		
GII	0.732	0.820	0.753	0.526	0.870	
GSI	0.635	0.708	0.642	0.696	0.685	0.901

#### **4.5.1 Model result and Hypothesis testing**

In this study, an analysis is conducted using a path diagram to demonstrate and examine seven hypotheses, ensuring the relationships of the suggested research model are clear. Latent variables are marked in blue and linked with manifest factors marked in yellow. For hypothesis testing, this study incorporates Partial Least Squares Structural Equation Modeling (PLS-SEM). The research evaluates both the outer and inner models for measurement and structural testing. The outer model confirms the validity and reliability of the constructs, while the inner model confirms the hypothesized associations among latent variables. Specifically, there are seven hypotheses examined in the study, which influence green supply chain integration and circular economy practices on sustainable green performance with green innovation acting as a mediator. According to Hair et al. (2022), the t-statistics value is  $t > 1.960$  and p-value is  $P < 0.05$ , are using hypothesis testing with 0.05 significance level and one tailed test, are recommended. In Figure 14, the result of SEM model diagram shows the contribution as empirical supporting evidence and demonstrating the applications of green supply chain integration with circular economy, offering policymakers and industrial personnel support to improve environmental and operational efficiencies.



**Figure 14:**SEM diagram (SmartPLS tool)

#### 4.5.2 Direct Influence Analysis

To analyze the direct influence and its impact on the independent variable and dependent variable in the SEM, hypothesized testing plays an important role and offers empirical backing. Based on conventional SEM guidelines, statistical significance is determined through the test of the t-statistics and p-values, where the t-value exceeds 1.960 and the p-value is below 0.05.

The results of Table 14 are summarized and show several statistically significant relationships. In this table, it is pointed out that Hypothesis H1a is accepted, which means green customer integration in circular economy (GCI→CE) significantly positively affects

sustainability performance with a path coefficient of 0.426, a t-value of 2.418, and a p-value of 0.002. Similarly, green internal integration has revealed a positive contribution to circular economy (GII→CE) ( $\beta = 0.537$ ,  $t = 2.661$ ,  $p = 0.004$ ), supporting of Hypothesis H1c. On the other hand, green supplier integration in circular economy (GSI→CE) does not significantly affect it directly ( $t = 0.731$ ,  $p = 0.232$ ), that means those factors lead to the rejection of Hypothesis H1b.

Beyond direct effects on mediation paths, both GCI and GSI exert a significant influence on Exploitative Green Innovation (EIGI), where a t-statistic of 3.105 and 3.324 and a p-value of 0.00 for both of those hypothesis, respectively, as evidenced in Hypotheses H2b and H3b are accepted. GII also confirmed a positive relationship with ERGI and EIGI, with the highest path coefficient ( $\beta = 0.624$ ,  $t = 3.483$ ,  $p < 0.001$ ), confirming Hypothesis H4a and H4b. This result highlights the role of green supply chain integration in facilitating efficiency and sustainability in green innovation when effectively integrated.

However, H2a and H3a are rejected, as hypotheses where  $GCI \rightarrow ERGI$  and  $GSI \rightarrow ERGI$  showed that the  $t=1.130$ ,  $p=0.129$  and  $t= 0.716$ ,  $p=0.237$  respectively. In addition, both types of green innovation (GI) contribute to the circular economy outcomes, where H5a and H5b are statistically supported and hypothesis are accepted with t-statistics 2.048 and 4.910 point and p-value less than 0.05 (0.020 and 0.000), echoing their strategic importance in sustainability-driven frameworks.

**Table 14:** Direct effects test results for structural equation models (Path coefficients)

	Influence	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T Statistics ( O/STDEV )	P Values	Remark
H1a	GCI→CE	0.426	0.431	0.167	2.418	0.002	Accepted
H1b	GSI→CE	0.177	0.172	0.242	0.731	0.232	Rejected
H1c	GII→CE	0.537	0.528	0.202	2.661	0.004	Accepted
H2a	GCI→ERGI	0.166	0.168	0.147	1.130	0.129	Rejected
H2b	GCI→EIGI	0.545	0.574	0.181	3.105	0.000	Accepted
H3a	GSI→ERGI	0.126	0.121	0.176	0.716	0.237	Rejected
H3b	GSI→EIGI	0.613	0.621	0.169	3.324	0.000	Accepted

	Influence	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T Statistics ( O/STDEV )	P Values	Remark
H4a	GII→ERGI	0.580	0.592	0.184	3.150	0.001	Accepted
H4b	GII→EIGI	0.624	0.629	0.179	3.483	0.000	Accepted
H5a	ERGI→CE	0.237	0.232	0.116	2.048	0.020	Accepted
H5b	EIGI→CE	0.640	0.603	0.130	4.910	0.000	Accepted

So, the study findings explain that most of the results collectively highlight the critical role of green supply chain integration and green innovation in leading successful circular economy programs and sustainable performance.

#### 4.5.3 Indirect Influence Analysis

The test of indirect effect checks if independent variables significantly influence the dependent variable—circular economy (CE) through mediating variables such as exploratory green innovation (ERGI) and Exploitative green innovation (IGI). Statistical thresholds for testing the significance of these mediation effects is same as direct influence analysis where a t-statistic value greater than 1.960 (one-tailed test) and a p-value smaller than 0.05 that means 5% significant level with indirect relationship.

As shown in Table 15, the findings from the hypothesis testing are statistically validated mediating paths between green supply chain integration and circular economy. For hypothesis H6a, the value is  $\beta = 0.426$ ,  $t = 2.418$ ,  $p = 0.002$  that indicates hypothesis is accepted and demonstrates that green customer integration (GCI) affects CE considerably by way of ERGI. So, the value represents that the effect of mediation is underscoring positively and creates importance of GI strategies to maximize efficiency of circular economy. Likewise, green internal integration (GII) shows a significant indirect effect by way of ERGI ( $\beta = 0.602$ ,  $t = 3.207$ ,  $p = 0.000$ ), validating H6c. By integrating ERGI principles, firms can enhance circular economy principles that influence long-term performance. However, the hypothesis H6b is rejected, which means the indirect effect of green supplier integration (GSI) via ERGI isn't significant ( $t = 0.660$ ,  $p = 0.255$ ).

In addition, EIGI-based mediation analysis also represents the meaningful results. Where GCI and GII indirectly influence CE through EIGI with path coefficients of 0.564 ( $t = 2.932$ ,  $p = 0.000$ ) and 0.399 ( $t = 2.648$ ,  $p = 0.004$ ) confirming Hypotheses H7a and H7c, respectively. However, hypothesis H7b is rejected with  $t = 1.112$ ,  $p = 0.133$  that GSI's mediating effect through EIGI is not significant.

**Table 15:** Indirect effects test results for structural equation models

	Influence	Original Sample (O)	Sample Mean (M)	Standard deviation (STDEV)	T Statistics ( O/STDEV )	P Values	Remark
H6a	GCI→ERGI→CE	0.426	0.431	0.167	2.418	0.002	Accepted
H6b	GSI→ERGI→CE	0.030	0.022	0.045	0.660	0.255	Rejected
H6c	GII→ERGI→CE	0.602	0.610	0.216	3.207	0.000	Accepted
H7a	GCI→EIGI→CE	0.564	0.571	0.178	2.932	0.000	Accepted
H7b	GSI→EIGI→CE	0.117	0.077	0.105	1.112	0.133	Rejected
H7c	GII→EIGI→CE	0.399	0.385	0.151	2.648	0.004	Accepted

So, the Indirect effects test results for structural equation models support that green customer integration and green internal integration are major contributors to enhancing circular economy performance with green innovation capacities as key enablers. The results highlight the strategic importance of combining innovation-facilitated sustainability practices in consolidating circularity results in organizational operations.

## **5 Discussion and Conclusion**

The current chapter provides an integrated explanation of the empirical findings presented in Chapter 4 and relates these to the theoretical assumptions, research questions, and hypotheses established at the outset of the research. The objectives of this chapter are to explain the interconnection among Green Supply Chain Integration (GSCI), Green Innovation (GI), and Circular Economy (CE) performance in the Finnish energy manufacturing industry by analyzing the result through hypothesis testing. By conducting the PLS-SEM model on the base of the Resource–Behavior–Performance (RBP) and Triple Bottom Line (TBL) theory, the current chapter also explains how green innovation behaviors and strategic integration practices support sustainable performance. This chapter also interprets the academic as well as practical significance of the findings, aims to build the outlines of managerial and policy implications, and suggests opportunities for further research. By integrating the findings of this study, this chapter highlights into limelight aligning the utilization of GSCI and GI methods for driving circular economy transformation in industries.

### **5.1 Summary and key findings**

In this section, discuss the key findings of this study according to the objectives which are the main goals of this investigation. Based on the results, the relationship of various variables and the strategic alignment of Green Supply Chain Integration (GSCI) and Green Innovation (GI) and their simultaneous effect on circular economy (CE) performance in Finland's manufacturing industry are described sequentially. At the end of the study, the summary offers new insights into how internal and external integration strategies and innovation behaviors together increase industrial sustainability and performance.

### **5.1.1 Relationship Between GSCI and CE Performance (Objective 1)**

Findings of the structural model confirm that Green Customer Integration (GCI) and Green Internal Integration (GII) strongly influence CE performance (H1a and H1c are supported); these results also supported the previous study. Yang et al. (2024) were emphasizing joint close collaboration with customers and internal integration as critical drivers of circular practices. Green Supplier Integration (GSI) does not show a statistically significant direct effect on CE performance (H1b is not supported), indicating that means green supply chain integration has some limitations in upstream coordination with green innovation capabilities in Finnish suppliers in the manufacturing industry. While supplier integration has been successful in other sectors (Zhu & Sarkis, 2004), in different contexts, it may have to be reinforced further to be as effective as the impact discovered on customers and internal spheres within this industry.

### **5.1.2 GSCI as a Driver of Green Innovation (Objective 2)**

This study constructs a strong relationship between GSCI and both forms of green innovation—exploratory (ERGI) and exploitative (EIGI). In fact, GII significantly impacts both ERGI and EIGI (H4a, H4b are accepted), and the importance of internal knowledge sharing, cross-functional cooperation, and employee engagement in fostering innovation is emphasized. Similarly, GCI and GSI have significant effects on EIGI (H2b and H3b are supported), suggesting that partnerships with outsiders enhance incremental (exploitative) innovation more than that of radical (exploratory) innovation (H2a and H3a are not supported). This finding warrants the argument that customer and supplier collaboration enhances compliance- and efficiency-based innovation (Chen et al., 2020), while innately transformational innovation may require stronger internal competencies or transformation within the ecosystem level.

### **5.1.3 Impact of Green Innovation on Circular Economy (Objective 3)**

ERGI and EIGI both play a meaningful role in CE performance (H5a and H5b are accepted), demonstrating that both exploratory and exploitative green innovation plays a vital role in fostering sustainable material flow and resource efficiency. Exploratory innovation involves radical innovation which offers the transformation of circularity for the long run through new technology, while exploitative innovation refers to short-run operational efficiency by enhancing production processes and procedures. Such evidence supports the TBL approach by shedding light on how environmental and economic goals can be met through innovation (Elkington, 1997).

### **5.1.4 Mediation Effect of GI Between GSCI and CE (Objective 4)**

The study also confirms the mediating role of GI between CE performance and GSCI. ERGI and EIGI specifically worked as mediators in this study model where the GCI and GII impact CE results and this model also supports H6a, H6c, H7a, and H7c. In this way, this model affirms affirming the applicability of the RBP model in explaining how relationship and resources capability are integrated and translated into outcomes of performance through mechanisms of green innovation behavior. Interestingly, Green Supply Integration also did not show strong relationship with circular economy through form of GI (H6b and H7b are rejected), suggesting a less behavioral diffusion of supplier-initiated programs toward circular goals. This again suggests that green strategies by suppliers in this sector may require further maturation or support mechanisms.

### **5.1.5 Empirical Analysis and Interpretation of Research Questions**

Based on empirical findings and observations of the thesis, these sections give a brief answer to the research questions. Findings of this thesis provide unambiguous answers to research questions. Firstly, according to the response of RQ1, the result approve that Green Supply Chain Integration (GSCI) plays very strong influence on green innovation (GI) in the Finnish manufacturing industry, and Internal integration (GII) was the strongest driver, which supported exploratory green innovation ( $\beta = 0.580$ ,  $t = 3.150$ ) and

exploitative green innovation ( $\beta = 0.624$ ,  $t = 3.483$ ) that indicates the Finnish organizations align strong internal coordination with both types of green innovations. On the other hand, green customer integration (GCI) and green supplier integration (GSI) were the leading forces behind exploitative innovation ( $\beta = 0.545$ ,  $t = 3.105$ ), while the impact of exploratory innovation ( $\beta = 0.166$ ,  $t = 1.130$ ) was negligible. So, the result indicates in this part that all three aspects of GSCI contribute significantly to shaping GI, where internal integration is significant in developing radical and incremental innovations, while customer and supplier integration are more adept at enhancing existing processes and technologies.

With respect to RQ2, the results found that strategic fit between GSCI and GI that drives the circular economy (CE) performance. In these stages, the results show that exploitative and exploitative innovation both contribute positively to CE performance where exploitative innovation contributes slightly higher on CE performance, specifically on resource efficiency, recycling, and waste reduction. The result also showed the direct relationships that were established between GCI and CE and GII and CE, but there could not be any direct impact on GSI. After that mediation analysis showed that CE performance is enhanced when GCI is paired with exploitative innovation, and when GII supports both exploratory and exploitative innovation. So, findings suggest that performance of circular economy not only depend on existing integration of Finnish manufacturing firms but also combining the right types of integration with appropriate path of innovation. Supplier integration was insufficient by itself to enhance circular economy performance that means this is the right time to focus on developing supplier partnership relationships to maximize their profit and potentiality.

Finally, concerning RQ3, Finland's policy systems, tight environmental regulations, and emphasis on circular economy goals create a propitious context that most likely amplifies the beneficial role of GSCI-GI-CE performance. However, GCI explore the positive impact on green innovation and CE performance which make strong relation with sustainability of Finnish manufacturing industry. Parallel to this, the limited role of supplier integration

may reflect structural problems with integrating variegated supplier networks against Finland's state-of-the-art sustainability agenda. In general, the findings validate the Resource–Behavior–Performance (RBP) model, illustrating that GSCI serves as the core resource, GI as the determinant behavior, and CE performance as the ultimate outcome.

## **5.2 Theoretical Contributions**

This research contributes to the young knowledge base for sustainable green operations in several ways. First, it conceptualizes GSCI as a green dynamic capability that forms the basis of innovation-driven circular activities. Second, green exploration and exploitative innovation explain behavior and highlight their degree of difference yet balancing roles in CE performance. Third, it verifies the RBP model in the context of sustainability by empirically linking resource integration, innovation behavior, and CE outcomes. Finally, the Finnish manufacturing industry context introduces a distinct European manufacturing perspective where regulatory acumen and ecological awareness offer a fertile ground for circular initiatives.

## **5.3 Managerial and policy Implications**

From a managerial point of view, the results highlight the strategic function of aligning internal processes and customer relations with green objectives to drive innovation and reduce circularity. Managers are encouraged to invest in employee training, cross-functional collaboration tools with clear organizational vision, all department work together and reduce environmental impact which enhance GII system to achieve organization performance. At the same time, strengthening customer engagement through sustainable co-design and green service innovation can accelerate CE performance. The modest effect of GSI indicates that organization needs to investigate the necessity for better supplier involvement models. Manufacturers may develop supplier green evaluation tools, reward environmental innovation, align environmental performance responsibilities, plan to settle environmental challenges and cooperate through common platforms for reuse waste, and product lifecycle management.

Additionally, innovation strategy must be two-pronged: balancing long-term radical change (ERGI) with short-term incremental improvement (EIGI), to provide both adaptability and efficiency. Policy makers can also have a pivotal role in setting policies that facilitate greening initiatives by suppliers and incentivize innovative partnerships. Subsidy, tax credit, or public-private partnerships on upstream integration can close current gaps. Circular economy transition roadmaps should also emphasize behavior mechanisms—such as innovation processes—that convert green strategies into performance outcomes, mapping industrial actors through staged sustainability transformation.

#### **5.4 Future Research**

Despite its value, the research is not flawless. The sample size is limited to give national and industrial context like the whole Finnish manufacturing industry. So, future studies would be able to draw upon another scientific method for sample selection like longitudinal methods to trace the evolution which ensure the integration-innovation dynamics over time and compare results across countries or more than one industry. This study is only conducted in quantitative research; to achieve more authentic results, mixed methods are suggested for further development and can uncover underlying organizational mechanisms to failures in supplier integration. Extending the model to incorporate digital technologies (e.g., IoT, blockchain), or organizational environmental culture and commitment could provide additional insights into making circular transformation a reality. This study emphasizes strategic implications of aligning GSCI with GI to achieve circular economy performance in Finland's manufacturing sector where Internal and customer integration exercises encourage incremental and radical innovations, respectively, which in turn significantly contribute to circularity. Supplier integration represents a weaker link, though developing it can further entrench the green performance trend.

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## Appendices

### Appendix 1. Questionnaire

#### Questionnaire Survey

##### Introduction to the Questionnaire Survey

This questionnaire is intended to collect data about master's thesis, under Industrial Management at the University of Vaasa. As part of my master's thesis, I am conducting a research study titled: **"Green Supply Chain Integration and Green Innovation Goals on the Circular Economy"**. The purpose of this study is to explore how the alignment between green supply chain practices and green innovation goals influences circular economy performance in the Finnish Manufacturing Industry. Your insights will contribute to a better understanding of how sustainability strategies can be effectively implemented in industrial operations.

This questionnaire consists of two parts:

- **Part 1: Background Information**                      **Part 2: Main Survey Questions**

The survey will take approximately **10–15 minutes** to complete. Your responses will be **anonymous** and used strictly for academic purposes. Thank you very much for your valuable time and support.

#### Part 1

##### Descriptive / Demographic Questions

1. **Your Job Title / Position:**

\_\_\_\_\_

2. **Department / Area of Responsibility:**

\_\_\_\_\_

3. **City / Location of the Company:**

\_\_\_\_\_

4. **Years of Experience in the Industry:**      5. **Type of Organization:**

a. Less than 1 year

a. Public

b. 1–3 years

b. Private

c. 4–6 years

c. Joint Venture

d. 7–10 years

d. State-Owned Enterprise

e. More than 10 years

e. Other:

6. **Company Size (Number of Employees):**

a. Less than 50

b. 51–200

c. 201–500

d. 501–1000

e. More than 1000

7. **Is your company involved in any green innovation or green supply chain projects?**

• Yes

• No

• Not sure

8. **Has your company adopted circular economy practices?**

a. Yes    b. No    c. Not sure

**Part -2**

using a Likert scale to assess perceptions related to green supply chain integration and innovation goals, Circular Economy, Triple Bottom Line and Financial Performance.

**Strongly Disagree= 1, Disagree=2, Neutral=3, Agree=4, Strongly Agree=5**

<b>Green Supply chain Integration = GCI+GSI+GII (Each construct consists of 6 items)</b>						
<b>Green Innovation= ERGI (construct consists of 6 items) + EIGI (construct consists of 6 items)</b>						
<b>Circular Economy = Construct consists of 6 items</b>						
<b>Construct</b>	<b>Description</b>	<b>Strongly Disagree (1)</b>	<b>Disagree (2)</b>	<b>Neutral (3)</b>	<b>Agree (4)</b>	<b>Strongly Agree (5)</b>
<b>Green Customer Integration (GCI)</b>	Our organization works together with key customers to achieve environmental goals.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Our organization agrees with key customers on environmental performance responsibilities.					
	Our organization works with key customers to reduce the environmental impact of our operations.					
	Our organization works with key customers to design, anticipate, and solve environmental problems.					
	Our organization works with key customers to determine methods for reducing the environmental impact of our products/services.					
	Our organization works with our key customers to accumulate and share environmental knowledge.					
<b>Green Supplier Integration (GSI)</b>	Our organization works together with key suppliers to achieve environmental goals.					
	Our organization aligns with key suppliers on environmental performance responsibilities.					
	Our organization works together with key suppliers to reduce the environmental impact of our activities.					
	Our organization works together with key suppliers to plan, anticipate, and settle environmental challenges.					
	Our organization works together with key suppliers to determine how to reduce the environmental impact of our products/services.					

	Our organization works in partnership with our major suppliers to collect and share environmental information.					
<b>Green Internal Integration (GII)</b>	All departments of our organization work together to achieve environmental goals.					
	In our organization, each department has a clear vision of its contribution to environmental performance.					
	All departments of our organization work together to reduce the environmental impact of our business.					
	All departments of our organization work together to plan, forecast, and solve environmental issues.					
	All departments of our organization work together to determine how to reduce the environmental impact of our products/services.					
	In our organization, all the departments emphasize the gathering and sharing of environmental information.					
<b>Exploratory Green Innovation (ERGI)</b>	Our organization is aggressively seeking demand beyond existing green products, processes, and services.					
	Our organization is aggressively embracing new green products, processes, and services.					
	Our organization is aggressively developing new green products, processes, and services.					
	Our organization is aggressively piloting new green products and services in the marketplace.					
	Our organization is aggressively promoting the commercialization of new green products and services.					
	Our organization is aggressively employing new green distribution channels.					
<b>Exploitative Green Innovation (EIGI)</b>	Our organization actively improves existing green products, processes, and services.					
	Our organization actively transforms existing green product lines, processes, and services.					
	Our organization actively introduces up-graded green products and services to the market.					

	Our organization actively aims to increase the efficiency of our existing green products and services.					
	Our organization actively achieves economies of scale in existing green markets.					
	Our organization is actively expanding the scope of green services for existing customers.					
<b>Circular Economy (CE)</b>	Our organization employs circular economic principles in its production operations.					
	Our organization recycles the by-products produced during production process.					
	Our organization utilizes reusable or renewable resources in equipment or infrastructure.					
	Our systems are designed to be repairable, modular, or long lifespan.					
	Our organization has established procedures for recycling or reusing retired equipment.					
	Our organization collaborates with partners or stakeholders in implementing circular practices considering environmental issues.					

## Appendix 2. Outer Loadings Table -SEM modeling

SmartPLSs software used for creating SEM modeling outer loadings table.

Outer loadings - Mean, STDEV, T values, p values						
	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics ( O/STDEV )	P values	
CE1 <- CE	0.887	0.883	0.043	20.832	0.000	
CE2 <- CE	0.890	0.883	0.047	18.960	0.000	
CE3 <- CE	0.874	0.868	0.045	19.489	0.000	
CE4 <- CE	0.827	0.817	0.085	9.705	0.000	
CE5 <- CE	0.846	0.842	0.053	16.024	0.000	
CE6 <- CE	0.900	0.898	0.033	27.259	0.000	
EIG11 <- EIGI	0.919	0.916	0.026	35.369	0.000	
EIG12 <- EIGI	0.900	0.898	0.030	30.460	0.000	
EIG13 <- EIGI	0.927	0.924	0.026	36.251	0.000	
EIG14 <- EIGI	0.867	0.859	0.060	14.554	0.000	
EIG15 <- EIGI	0.904	0.902	0.036	25.265	0.000	
EIG16 <- EIGI	0.905	0.901	0.039	23.172	0.000	
ERG11 <- ERGI	0.844	0.846	0.048	17.727	0.000	
ERG12 <- ERGI	0.833	0.823	0.113	7.383	0.000	
ERG13 <- ERGI	0.953	0.952	0.018	53.210	0.000	
ERG14 <- ERGI	0.939	0.940	0.017	55.637	0.000	
ERG15 <- ERGI	0.845	0.843	0.052	16.101	0.000	
ERG16 <- ERGI	0.872	0.874	0.044	19.756	0.000	
GCI1 <- GCI	0.891	0.877	0.058	15.492	0.000	
GCI2 <- GCI	0.888	0.876	0.058	15.338	0.000	
GCI3 <- GCI	0.940	0.935	0.030	31.393	0.000	
GCI4 <- GCI	0.888	0.885	0.039	22.796	0.000	
GCI5 <- GCI	0.920	0.920	0.024	38.711	0.000	
GCI6 <- GCI	0.901	0.897	0.037	24.169	0.000	
GII1 <- GII	0.859	0.851	0.056	15.350	0.000	
GII2 <- GII	0.833	0.818	0.085	9.844	0.000	
GII3 <- GII	0.920	0.920	0.033	27.713	0.000	
GII4 <- GII	0.946	0.948	0.013	71.781	0.000	
GII5 <- GII	0.915	0.913	0.029	31.286	0.000	
GII6 <- GII	0.730	0.706	0.162	4.508	0.000	
GSI1 <- GSI	0.930	0.920	0.045	20.843	0.000	
GSI2 <- GSI	0.877	0.863	0.092	9.532	0.000	
GSI3 <- GSI	0.918	0.911	0.037	24.814	0.000	
GSI4 <- GSI	0.881	0.879	0.041	21.284	0.000	
GSI5 <- GSI	0.909	0.909	0.031	29.136	0.000	
GSI6 <- GSI	0.888	0.892	0.032	27.924	0.000	